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Contents.

	PAGE
Forthcoming Events	37
Three Foundry "Grouses"	37
Refined Iron	37
The Critical Examination of Steel Castings	38
Random Shots	40
Application of Pulverised Coal to Metallurgical Furnaces	41
Methods of Testing Cast Iron	46
Buying Electric Power	50
Trade Talk	52
Correspondence	52
New Companies	52
Personal	52
Obituary	52
Iron and Steel Markets	54
French Engineers Visit Glasgow	54
Reports and Dividends	54

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

MAY-OCTOBER.
North-East Coast Exhibition at Newcastle-on-Tyne.

JULY 16-27.
International Aero Exhibition at Olympia, London, W.

Three Foundry "Grouses."

That the foundry industry has a number of "grouses" is merely indicative of its desire to make progress. Their ventilation in the columns of the Press is desirable, because it gives a lead to those who direct its activities. Most of the "grouses" reach us verbally, and they can generally be ameliorated by a full explanation of the exigencies of the situation. A typical grouse, which quite often reaches us, is that the Papers read before the Institute of British Foundrymen are too academic. This is usually accompanied by a sigh for a type of Paper, alleged to have been presented in the happy days before the War. We can assure these people that the earliest Proceedings of the Institute show very definitely that the "practical" side was "practically" ignored. There was a good deal of discussion about the inherent properties of cast iron, but research and logical thought have combined to put forward a reasonable explanation, which is at least worthy of provisional acceptation. The only desideratum worth considering in this connection is that the provision of practical Papers is in the hands of practical men. The Institute not merely welcomes them, but will lend its resources towards aiding their production.

A second "grouse" is that there was only one Paper dealing with steel foundry practice presented to the recent Congress. We can assure that section of the industry that it was no fault of the Committee concerned. The Council had perforce to accept a very large number of foreign exchange Papers, which consequently limited the number of those which could be presented by the home industry. Moreover, we suggest that at least half presented matter germane to the steel foundry industry, as it shares with the iron and non-ferrous branches an interest in sands, facings, recruitment and training of personnel, sulphur and crystallisation.

A third "grouse," and one with which we have some sympathy, is rather widespread amongst founders living in localities not covered by a section of the Institute. It refers to the fact that they have but one opportunity per annum of attending a meeting. It is felt that there should be one meeting every year in London, devoid of any social events, except, perhaps, a banquet, and a second one, either in a large industrial centre or abroad. It does appeal to us that such a scheme is well worth the serious attention of the Council.

Refined Iron.

Reference was made in a recent issue to the risk of heterogeneity introduced by melting mixtures, the compositions of the constituents of which were rather wide apart and whose melting points were consequently also rather wide apart. It was suggested in this connection that in order to get a good product when melting foundry mixtures, the various constituents of the mixture should be as close as possible to the ultimate composition desired. It must be freely acknowledged that few things have been more striking during the past few months than the growing use of refined irons. We have always been inclined to regard as a weakness on the part of the founder the demand for particular compositions of pig-iron from the blast-furnaceman, since proper mixing of irons ought to enable the founder to use whatever material happens to be available. This, however, we admit to presuppose the presence of a chemist and laboratory control, which are not, of course, always available. As a result the founder continues to demand iron to a specified analysis, and the blast-furnaceman continues to experience difficulty in providing it with certainty and regularity. The problem has now been solved by a process which on the face of it would appear to be uneconomic, namely, the introduction of a second melting process. Apparently, however, this uneconomic proceeding justifies itself even under the present difficult market conditions. It will be obvious that the use of such refined iron enables a much closer approach to fulfilment of the conditions laid down as desirable in metal mixtures than is possible in the case of straight mixtures of pig-iron and scrap. In other words, it enables as close an approximation as possible of the composition of the raw material to the finished product. Hence the scope for refined iron.

There is, however, one temptation that must be resisted by the makers of refined iron. They may be presumed to have at heart the necessity for establishing in the minds of founders the idea that refined iron is essentially a high-quality product. They must, therefore, refrain from using in the manufacture of this would-be high-quality product scrap of a type which by reason of its composition and its size is likely to produce a refined iron as much lacking in homogeneity as the most irregular product of the blast furnace. Refined iron, in fact, must take care that it does not cease to be refined.

The Critical Examination of Steel Castings.*

By G. F. Gillott, B.Met.

(Communication from the Research Department, Woolwich.)

The last few years have been marked by decidedly increased demands on the quality and service expected of the products of the steel foundry. With the tendency towards higher stresses, higher temperatures and reduced weight in the zealous quest after higher thermal and mechanical efficiency, the engineer's requirements have, on the one hand, become extremely exacting. On the other hand, the competition of old rivals of steel castings has become more keen. The ancient art of cast-iron founding has at last been put on a more scientific basis under precise metallurgical control, whilst the smith's art has progressed until quite large and intricate forgings of lower cost and superior characteristics have been made possible by recent developments in drop-stamping and machine-forgings. The new problems can only be met by basing advances in steel foundry practice on existing knowledge and on the results of special investigations interpreted in the light of such information as is available from a critical examination of steel castings. The long-standing practice of breaking up an occasional casting and examining the fracture gives a limited amount of information; but the recent developments of radiology enable an equal or greater amount of information about the presence and distribution of defects to be obtained without the necessity of destroying the casting.†. By interposing the casting to be examined between a piece of photographic film and a very powerful X-ray tube, a shadow picture is obtained which shows on the positive print less-dense patches corresponding to the defects, which offer less resistance to the passage of the rays than sound metal. To yield the "hard," short wavelength X-rays necessary to penetrate such a dense substance as steel, a very powerful hot-kathode tube is used with an applied potential of 200 to 400 kilovolts. With the maximum power available it is possible to penetrate about 4½ in. of solid steel and to detect in this a flaw equivalent to 3 per cent. of the thickness of the section. Typical radiographs are shown in Figs. 1, 2, 3 and 4, in which various defects are denoted by light areas.

Of still more importance than knowing the presence of a defect is learning the source of its origin. In many cases this is not revealed with certainty by X-ray examination and detailed examination of sectioned castings is essential to arrive at a solution of the problem of eliminating the defects. Steel ingots have been intensively studied for many years and the results applied with great advantage to the production of sound ingots showing a minimum of segregation. The question of soundness in steel castings is a different and, in many respects, a more difficult problem, but methods which have profitably been employed for the examination of ingots are applicable with suitable modification to castings also.

Briefly, the methods employed in studying sectioned-ingots have been macroscopical and microscopical examination, chemical analysis and hardness testing. The application of the first two of these to steel castings will be considered.

Macroscopical Examination.

The machined-surface of the section is ground, or ground and polished, with fine emery and is then ready for the further treatment. This consists, in the first place, of sulphur-printing. Gaslight photographic-paper, soaked in 5 per cent. solution of sulphuric acid, is laid face downwards on the specimen, and close contact preserved for about two minutes. On removal from the specimen, the print shows brown coloration of silver sulphide at positions where the emulsion has been in contact with sulphide in the

MR. G. F. GILLOT, B.MET.

specimen. The record is permanent after fixing with "hypo." and washing in the usual way. The sulphur-print gives a graphic representation of the degree of heterogeneity, based on an unequal distribution of sulphide. It is known that sulphur, carbon and phosphorus segregate together and, therefore, the sulphur print indicates the general heterogeneity of the steel. Typical sulphur-prints are shown in Figs. 5, 6 and 7. Fig. 5 indicates the tendency of segregation to occur in the thicker section at the junction of four walls. Figs. 6 and 7 show V-segregations of sulphide, which on a larger scale are a common feature of steel ingots. Fig. 7 shows an interesting type of heterogeneity which is common in steel castings, consisting of a surface layer of material differing from the rest of the casting. All these types of heterogeneity are also shown by other methods of examination and discussion of their meaning is, therefore, deferred until later.

The surface of the section after sulphur-printing is usually etched with some suitable etching-medium. This may be:—(*a*) 10-per-cent. solution of nitric acid in alcohol; (*b*) Heyn's reagent, consisting of 8- to 10-per-cent. solution of copper-ammonium-chloride in water; and (*c*) Humfrey's modification of Heyn's reagent, starting with the neutral reagent and following with Heyn's reagent containing progressively increasing percentages of hydrochloric acid, up to 5 to 10 per cent. by volume of concentrated acid.

Of these reagents, nitric acid, depending for its action on the carbon segregation, fails to show up the primary crystal structure if the casting has received an efficient annealing resulting in uniform distribution of the carbide. Humfrey's reagent, however, depends on characteristics which are less affected by annealing and has the advantage that the surface need not be so carefully prepared. It is very suitable for deep etching of fairly coarse structures. Since the selective action of this reagent depends on the distribution of phosphorus and possibly also of oxygen, both of which exist as solid-solutions in cast steel, a more continuous record of the primary structure is revealed than by sulphur, which is present chiefly in isolated globules of sulphide. The result of etching is, therefore, to show not only the general heterogeneity but also the dendritic structure of the primary-austenite crystals. The reagent first attacks the purer material in the cores of the primary dendrites, so that if the dendrites are very small,

FIG. 1.—RADIOGRAPH, SHOWING CAVITY AND CHAPLET.

FIG. 2.—RADIOGRAPH, SHOWING TRANSVERSE CRACKS IN CYLINDER.

FIG. 3.—RADIOGRAPH, SHOWING CIRCUMFERENTIAL CRACKS IN CYLINDER.

FIG. 4.—RADIOGRAPH, SHOWING CRACKS AT BASE OF BRACKETS.

* A Paper read before the recent International Foundrymen's Congress.

† V. E. Pullin, F.T.J., 1928, *39*, 357.

they are obliterated by deep etching, owing to the interdendritic material being dissolved away by outward attack from the core. Equiaxial crystals show only as indefinite dots. Fig. 8 shows a photograph of a section etched by this method. An advantage of this process is that the structure stands out in relief and direct-contact prints can be obtained on "glazed art" paper by means of printer's ink, as illustrated by Figs. 9, 10 and 11, which are photographs of such prints. The segregates stand out in relief on the etched surface and, after rubbing with fine emery paper, appear light. In the ink-print, the segregates are represented by the dark areas, as in the sulphur prints.

Macroscopical examination frequently indicates the regions which may profitably be examined more minutely by means of the microscope.

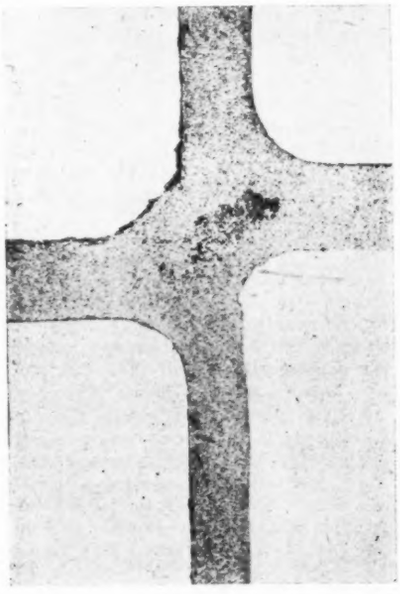


FIG. 5.—SULPHUR PRINT, SHOWING SEGREGATION AT THE JUNCTION OF FOUR WALLS.

FIG. 6.—SULPHUR PRINT, SHOWING V-SEGREGATION.

Microscopical Examination.

Certain features of the general structure of a casting are revealed by microscopical examination of specimens taken from any convenient position in the casting, for example, from the cast-on test-bars. The most important indications of microscopical examination applied as a routine test have reference to the efficiency of the annealing received. The structure of the cast steel before annealing consists of large grains of pearlite in which angular fragments of ferrite have separated along the cleavage planes, giving a coarse "lattice" type of structure possessing poor mechanical properties. The object of annealing is twofold: (1) To cause a recrystallisation and refinement of the large grain size, and (2) to relieve internal stress. The former necessitates heating for a considerable time above the upper limit of the critical range; the latter is effected at a much lower temperature and is almost complete at about 550 deg. C. The danger of insufficient annealing lies not so much in persistence of internal stress as in the inferior mechanical properties of the steel, shown particularly in a low true-elastic-limit and poor impact figure. The incompletely-annealed structure shown in Fig. 12 was associated with slight but unimportant stress, but the limit of proportionality and impact figure were both low and were restored by a more efficient annealing. The actual test-figures before re-annealing were: Limit of proportionality, 7 tons per sq. in.; Izod impact-figure, 5½ ft.-lbs. After re-annealing these improved to 11 tons per sq. in. and 18 ft.-lbs. The yield-point and

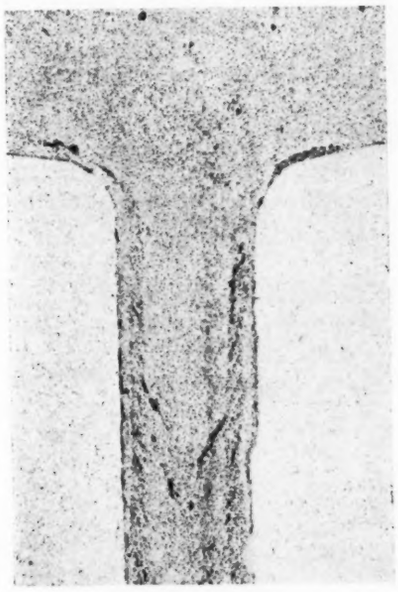


FIG. 7.—SULPHUR PRINT, SHOWING V-SEGREGATION AND "CHILL" EFFECT.

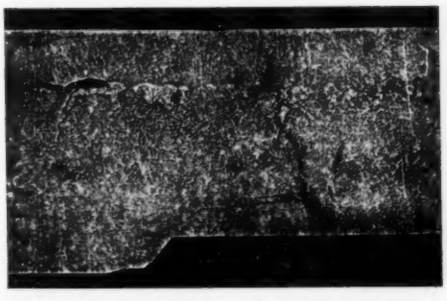


FIG. 8.—ILLUSTRATION SHOWING MACRO-STRUCTURE, INCLUDING CAVITIES, CRACKS AND SEGREGATES.

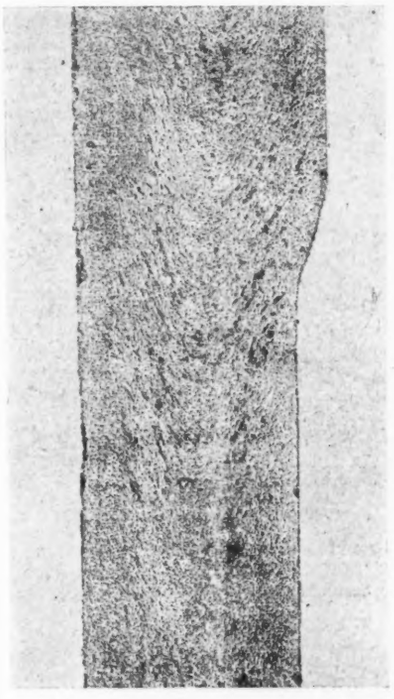


FIG. 9.—INK MACROPRINT, SHOWING V-SEGREGATION.

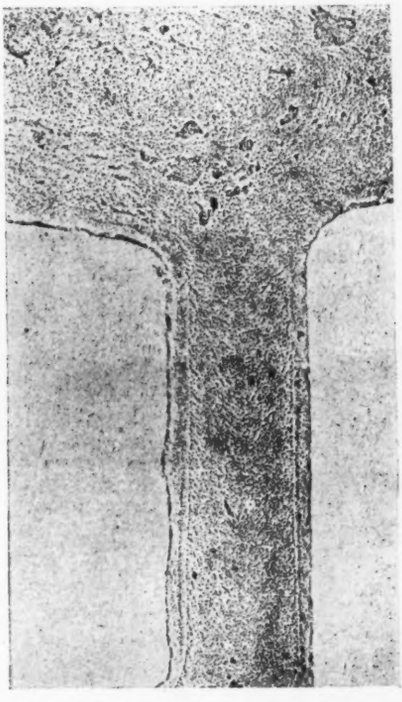


FIG. 10.—INK MACROPRINT, SHOWING V-SEGREGATION AND "CHILL" EFFECT.

elongation were also improved, whilst the tensile strength only increased slightly. The structure after re-annealing is shown in Fig. 13. The "as-cast" structure of another casting is shown in Fig. 14, whilst Fig. 15 shows the refined structure resulting from an efficient annealing. A further effect of annealing is the partial balling-up of sulphide films which may form initially round ferrite and pearlite grains, and which in that position are very detrimental to the mechanical properties. Such films, some practically continuous and some partially balled-up, appear in the ferrite bands in Fig. 16.

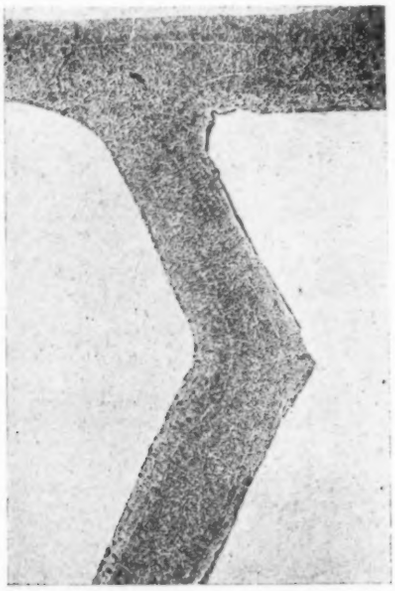


FIG. 11.—INK MACROPRINT, SHOWING "CHILL" EFFECT AND DENDRITIC STRUCTURES.

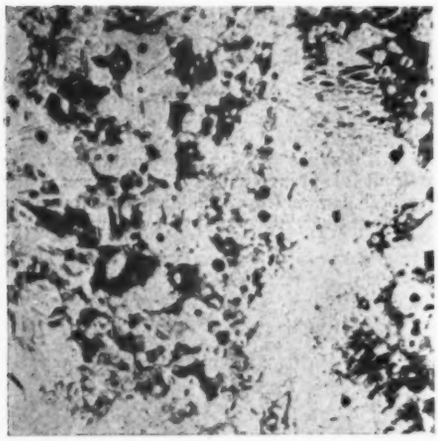


FIG. 12.—MICROSTRUCTURE OF AN INCOMPLETELY ANNEALED STEEL CASTING. × 100.

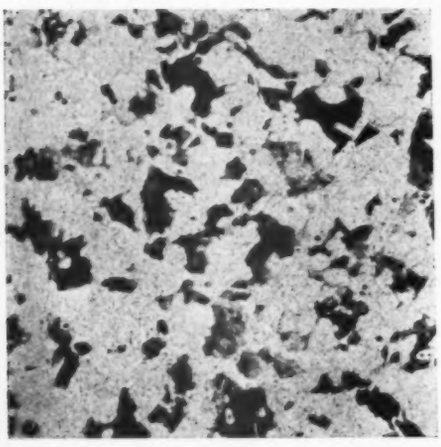


FIG. 13.—MICROSTRUCTURE OF EFFICIENTLY ANNEALED CASTING. × 100.

FIG. 14.—MICROSTRUCTURE OF STEEL CASTING, "AS CAST." × 15.

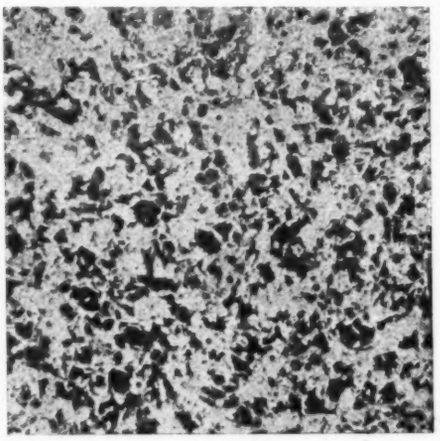


FIG. 15.—MICROSTRUCTURE OF STEEL CASTING, AFTER ANNEALING. × 25.

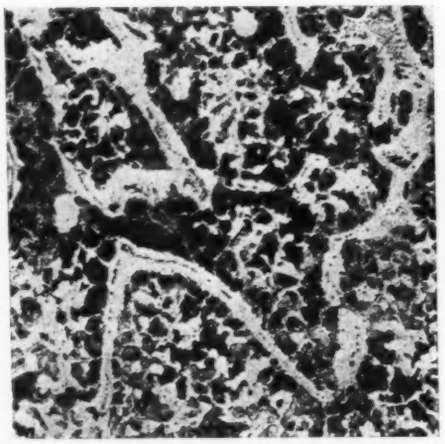


FIG. 16.—MICROSTRUCTURE OF STEEL CASTING, SHOWING SULPHIDE FILMS. × 100.

(*To be continued.*)

Random Shots.

Talking recently of literary *faux pas* over railway matters, I am reminded how often writers of considerable prestige do display their ignorance. Sport used to be a favourite pit-fall; wasn't it "Ouida" who talked of the men rowing in the Boat Race "with their eyes fixed upon the goal," and added (stroke being the hero of the tale) that "they all rowed fast, but stroke rowed the fastest." I cannot for the moment recall certain celebrated "gaffes" anent the Derby; can any reader help me?

* * *

These, of course, are mistakes that arise through ignorance, and, as a rule, ignorance that is so far unconscious of itself that it makes no effort to repair its deficiencies. There must after all be text-books from which a doubtful author could ascertain the necessary details of sporting, industrial, and domestic processes. If there isn't, it's time there was. . . . Nowadays, of course, sport is far too familiar to us all for serious mistakes to be possible, and in its place we find the amateur struggling with the machinery of crime detection. The powers that be at Scotland Yard—always supposing that they share the popular taste for detective fiction—must have many a quiet smile over the doughty deeds attributed to them by the tellers of tales who draw less upon their experience than upon their imagination. What is more, by this time enough chief inspectors must have been created to populate at least six Scotland Yards! At the same time, fiction is fiction, and, personally, I would rather take the risk of my detective behaving in a slightly unorthodox manner than read a thriller like one that came my way lately (which shall be nameless) that bore the semblance of a manual on the higher mathematics, the art of chess, the psychology of the abnormal, and the methods of the New York police. I ask you!

* * *

Quite different are the mistakes that are made, often deliberately, by writers of imaginative work. I remember, when the original "Robot" play was put on in London, visiting it with a man of typically scientific mind, who flatly refused to consider the play interesting or even entertaining because it was scientifically impossible. That anyone should, for the sake of writing an imaginative play or novel, frankly overstep the bounds of probability, struck my friend as a piece of gratuitous insanity, while I, in company with a large number of my fellow-playgoers, found it, as Mr. Pepys might have said, "vastly diverting."

* * *

I heard a good yarn the other day at the expense of Lord Birkenhead and that illustrious gentleman's pronounced tastes in dress. One morning during a conference in Paris to which he was a delegate it became necessary to ask his advice at a somewhat early hour. His lordship appeared in a dressing-gown of striking and futuristic design. "Ah," said the dazzled fellow-delegate who awaited his coming, "are these, then, the famous ceremonial robes of which I have heard so much?"

MARKSMAN.

Application of Pulverised Coal to Metallurgical Furnaces.*

By H. W. Hollands, B.Sc., A.M.I.M.E., and E. C. Lowndes, F.Inst.F.

The authors present this Paper with a certain amount of diffidence, since it deals principally with the application of pulverised coal to steel furnaces. A large amount of research and experimenting has been done in this country with regard to iron processes, but difficulty has been experienced in obtaining information, whilst it has not been found possible to obtain permission to publish any of the results. It is, therefore, fortunate that work has been carried out on the Continent, and much available information with regard to melting and annealing of malleable iron has been obtained from France and America. Before dealing with specific applications, it would perhaps be as well to give some details of the basic principles essential to the successful application of powdered fuel to metallurgical processes.

MR. H. W. HOLLANDS.

There are two main divisions in the type of plant that can be installed, namely, the "bin-and-feeder" system or the "direct-fired." Both have their advantages and disadvantages, and it is entirely a question of local conditions which method is utilised. Obviously, in the case of one or two small furnaces, there is little or nothing to be said for the central system, whilst equally, on a plant having, say, twelve or more furnaces, it is difficult to justify the unit system.

Advantages of the Bin and Feeder Method.

With regard to the systems themselves, the direct-fired system has nothing to commend it when compared with the central-station arrangement. The essence of the successful application of pulverised coal to metallurgical furnaces is fine pulverisation, and this is difficult, if not impossible, to obtain with unit pulverisers for reasons which will be explained later. Briefly, the advantages of "bin-and-feeder" system are as follows:—(1) Coal can be accurately dried (using the modern form of rotary drier, the cost of drying varies between 18 to 30 lbs. of coke per ton of coal, depending on the initial moisture content); (2) the fineness of pulverisation remains constant throughout the life of the rolls and can accurately be adjusted to suit the particular conditions obtaining; (3) the mills, whatever their type, are of the slow-speed variety and the maintenance cost, therefore, is lower than with unit mills; (4) pulverised coal is stored in small bunkers over each furnace and is de-aerated before storing. This results in an accurate degree of coal and air mixture and, at the same time, gives a measure of reliability, inasmuch as failure of the pulverising plant does not necessarily shut down one or more furnaces; (5) inasmuch as supply of pulverised coal is always available, unusual or peak loads can be met instantly; (6) lower power consumption, due largely to the much lower speed at which the mills operate.

Disadvantages of the Unit System.

Alternatively, the disadvantages of the unit system are:—(1) Failure of the mill or motor means that the furnace in question is definitely out of action; (2) pulverisation rapidly deteriorates from the first moment that the mill is put into operation; (3) moisture has a serious effect not only on the fineness of the pulverisation but upon the mill maintenance and power costs; (4) any attempt to meet an unusual or peak load usually results in stalling the mill or motor; and (5) the plant is incapable of supplying a mixture of coal and air as accurate as that obtained with the central system.

With regard to the degree of pulverisation required, the finer the coal can be ground the better from the combustion point of view, but, obviously, there must be a point beyond which, on account of economical questions, it is not possible to go, and it may be perhaps convenient to define the degree of pulverisation required as follows: The coal must be ground to such a point that combustion is practically instantaneous; the minimum amount of unconsumed carbon must be left in the ash, whilst it must be possible to obtain maximum amount of CO_2 in the flue gases at the conclusion of the operations. In one experiment which has come under the authors' view the coal was ground so that 95 per cent. would pass through a 300-mesh. Whilst this is ideal from the combustion point of view, it was obviously obtained at a very high cost which would eliminate the other savings to be obtained from the use of pulverised coal.

Importance of Dry Fuel.

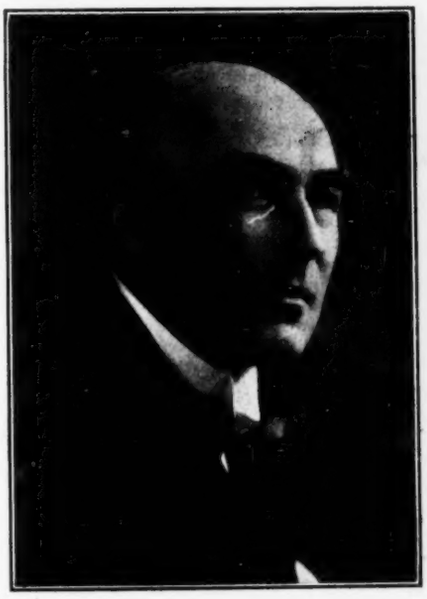
Generally speaking, the coal needed for heating and melting furnaces should be dried to less than 1 per cent. and pulverised so that 98 per cent. passes through 100-mesh screen. It is not the percentage through 300- or 200-mesh that gives efficient operation in this work but the lack of cobble-stones left on the 100-mesh screen. At the same time all through a 100-mesh would not be commercial. The ash-content and the nature of the ash is a further serious consideration for the designers of the furnaces. In operations such as puddling or any process where the metal is in a molten state, it is nearly always possible to flux the ash which necessarily settles on the metal, and this can be tapped off with the furnace cinder. Obviously, with processes such as billet- or plate-heating, no such arrangement is possible, and very careful consideration must be given to where and in what form the ash will be deposited and the effect, if any, it will have upon the metal treated and upon the brickwork.

In one particular case, which the authors will describe later in the Paper, very serious trouble was caused through the melting of the furnace bottom, through the action of the acid ash on the basic bottom. After very much trouble and expense a bottom made of chrome-brick was put in, and no further trouble has been experienced. Here, again, no definite laws can be enunciated, but each application must be considered on its own merits, and in no case should it be impossible to design plant in such a way that the ash will give no serious trouble or result in high maintenance charges. Obviously, however, the better policy is to buy coal with as low an ash content as possible, having due regard to the B.T.U.'s per penny.

Advantages of Pulverised Fuel.

Before describing in detail actual applications, it would, perhaps, be as well to set out the theoretical advantages to be obtained from the use of pulverised coal. These are as follows:—

(1) The ability to utilise efficiently a cheaper grade of fuel. This does not necessarily mean a poorer grade, but inasmuch as it is possible to use a very small slack, the price is invariably lower than that obtaining for furnace coal. The difference in price obviously depends upon the locality, but it may be taken that reduction in price will not be less than between 7s. and 10s. per ton of coal.



MR. E. C. LOWNDES.

(2) *Flexibility*: Coal, if pulverised sufficiently finely, is as flexible as oil or gas, and whilst this point is not so important on furnaces as it is on boilers, it is certainly one worthy of consideration.

(3) The time required for heating the particular metal under consideration is usually reduced, the reduction amounting to probably 20 per cent.

(4) Banking, starting up and stopping losses materially reduced.

(5) In view of the perfect combustion which can be obtained, actual quantity of coal per ton of metal consumed is reduced to the extent of from 25 to 50 per cent. below that obtaining with hand-fired furnaces.

Against these advantages it is necessary, of course, to bear in mind that pulverisation and maintenance account for a certain amount of money, the actual figure depending upon the type of plant installed, the nature of the coal to be pulverised and other local conditions, but a figure varying between 2s. 6d. and 5s. could reasonably be taken and would, with one exception, cover every case which has had the attention of the authors. Coming to actual applications, which would probably be of more interest

* A Paper presented to the recent International Foundrymen's Congress.

than mere theorising, the authors have had experience in the application of pulverised coal to furnaces for skelping, billet and plate heating, malleable-iron annealing and puddling, and, to a much lesser extent, with open-hearth furnaces.

Examples from Practice.

With regard to skelping furnaces, an existing furnace at the works of Messrs. Edward Smith, Limited, Wednesbury, was put into operation approximately five years ago, and has, within reasonable limits, proved extremely satisfactory. The directors of this concern very kindly put their furnace at the disposal of the authors, who posed fourteen questions as follows:—(1) How long has the furnace been in operation? (2) output per hour of finished material? (3) Coal consumption? (4) Temperature required? (5) Is heating uniform? (6) Coal consumption when hand fired? (7) Has output increased? (8) How does the present cost of coal per hour compare with hand firing? (9) How has installation of pulverised coal affected: (A) labour charges and (B) quality of material? (10) H.P. consumed by pulveriser motor? (11) Maintenance costs on furnace and pulveriser? (12) Has ash affected the operation materially, and has moisture affected the operation materially? (13) Has the application of pulverised coal materially affected the life of the furnace? (14) Are you satisfied that, in installing this equipment, you came to the right decision?

To these several questions the answers are given below:—(1) Approximately five years. (2) 35 cwts. per hour. It will be observed that the actual time for heating the material is but part of the period occupied from the time of charging until it is withdrawn from the furnace. (3) Four and a-half cwts. per hour, or 2.56 cwts. per ton. This consumption during the actual period of working is 6 cwts. per hour, or 3.4 cwts. per ton. This is the average consumption charged to working hours, but includes fuel used getting furnace up to working temperature before 6 a.m. This furnace is in operation for two shifts a day, and the firm is convinced that, if it was able to work for three shifts a day, both of the above coal-consumption figures would be materially reduced. (4) 1,200 to 1,400 deg. C. (5) Subject to waste gas ports being clear and adjusted properly, combined with suitable adjusting of deflection valve, a good uniform heat is obtained. (6) (A) 5 cwts. and (B) 7¼ cwts. (7) Approximately 5 to 6 per cent. (8) Fuel now used costs 14s. 6d. per ton, against what would be present cost of previous fuel 22s. 6d. per ton. (9) (A) Additional labour charges owing to dry fuel being necessary and for cleaning of furnace more frequently, and (B) less oxidisation of material, saving approximately 1 per cent. of weight.

(10) Approximately 10 h.p.

(11) Including cost of renewals and spares, labour, bricks and bricklayers time, it is estimated to be 2s. 8d. per ton of fuel pulverised. This may appear to be rather high, but as an explanation it should be recorded that renewals have cost £30 per annum since the machine was purchased, and, in addition to this, there has been purchased a spare rotor shaft (not included in these figures). We find that the fitter's and bricklayers' time has been heavier than estimated by suppliers of the machine and furnace.

(12) (A) Yes. All ports have to be daily cleaned and working bed of the furnace scraped; also the combustion chamber has to be cleaned weekly; (B) if fuel contains over 6 per cent. moisture, the temperature and the effective working of the furnace is interrupted.

(13) Nothing appreciable.

(14) Yes; the firm is satisfied with its decision, but it would like to add that it has been found by experience that a low-grade fuel with high ash content will not do the work or permit the furnace to be heated to proper working temperature, and dust would be a serious hindrance to carrying on.

The authors have many times inspected this furnace in operation. The material to be welded consists of strip steel or wrought iron which, after leaving the furnace, is bent and subsequently welded to form a welded tube. Obviously, the question of ash is important, since extensive deposit would not only materially affect the life of the mandrels, but also it would affect the strength of the weld. Neither of these troubles have been experienced at Messrs. Edward Smith, Limited, and tubes produced from the powdered-coal furnace are equal to the usual high standard which is always maintained at these works.

It will be observed from the answers to the questions that the principal saving is from the lower price of coal. Saving from weight of coal consumed is probably offset by the wear and tear of the pulveriser and maintenance of the furnace. It is, however, certain that, in the light of modern experience, the furnace could be so designed that the troubles that they have had through ash deposit can be materially reduced. Fig. 1 shows several views of Messrs. Edward Smith's furnace, which is fired on the unit system.

A Billet Furnace.

The same set of questions was submitted to Messrs. F. R. Simpson & Company, Limited, who seven years ago put into operation a pulverised-coal-fired continuous re-heating furnace for billets. Their answers to these questions are as follow:—

(1) Powdered-fuel-fired furnace has been in operation about seven years.

(2) Maximum possible output, 6 tons per hr. This furnace supplies a 9-in. merchant mill rolling a great variety of finished product, necessitating frequent roll changes, and bringing down average throughput to about 2½ tons per hr., and the coal consumption naturally varies according to size of finished product.

(3) The mill is working five days per week, 16 hrs. per day, and the furnace has to be kept in the other eight hours. Including heating up the furnace and keeping in during the idle shift, the coal consumption is 2.93 cwts. per ton of steel heated. Less the fuel used in keeping in the furnace during the idle shift, the consumption is 2.55 cwts. per ton of steel heated. Less the fuel used in heating up and keeping in, *i.e.*, actual working hours, the consumption is 2.16 cwts. per ton heated. These figures are the average for six months' working, with an average throughput of 2.57 tons per hour. With a throughput of 4 tons per hour, there is a coal consumption of 1.6 cwts. per ton of steel heated, and 6 tons per hour, 1.3 cwts. per ton.

(4) The temperature attained about 1,300 deg. C., whilst the combustion chamber temperature reaches 1,600 deg. C.

(5) The billets are uniformly heated and well soaked.

(6) The coal consumption before installing pulverising coal, about 4½ cwts. of coal per ton.

(7) Output has increased slightly.

(8) Coal costs have decreased.

(9) (A) Labour charges about the same; and (B) little or no difference in quality of material compared with that from gas-fired furnace billets uniformly heated and well soaked. The waste is the same.

(10) The power consumed by the pulveriser is approximately 19 units per hr., *i.e.*, 7.6 pence per ton.

(11) *Repair Costs.*—On installation repair costs were great owing to severe refractory troubles, due principally to furnace design. By using suitable refractories, suitable furnace design and suitable pulverising and blowing equipment, this trouble has been very much lessened. The repair costs are:—Material, 7s. 9d. per ton of coal, less undetermined credit for stocks of materials and labour, 11d. per ton of coal.

(12) (A) No ill-effects from dust are experienced, although this depends upon the quality of the fuel used. Using a good-quality fuel, screened beans with an ash content of 5 per cent. or 6 per cent., yet fusible, most of the ash is extracted in a fused condition from the combustion chamber. Trouble has arisen when using inferior fuel with 20 per cent. ash, of an infusible character, when the dust more or less chokes up the furnace and insulates the billets. (B) Moisture.—No ill-effects experienced. The fuel as purchased contains about 9 per cent. moisture, dried by flue gases to about 4 per cent. before entering pulveriser.

(13) *Life of Furnace.*—This is quite satisfactory, but it is necessary to do a little patching to the refractories in the combustion chamber, say every six months.

(14) Satisfied.

Considerable trouble has been experienced by Messrs. F. R. Simpson, due to failure of the furnace bottom, but by plating the furnace with chrome bricks they appear to have overcome this trouble, and, as will be seen from the answer to question (13) very little work is now necessary to keep the furnace in working condition. The furnace in question is about 30 ft. long by 5 ft. 6 in. wide, and has end charging side discharging. In view of the fact that, before equipping with pulverised coal, the furnace was gas-fired, the saving shown is considerable, since it is usually difficult to show any appreciable saving in favour of pulverised coal when compared with gas-producers. Here, again, this furnace is direct-fired with unit pulveriser.

Coming to a subject which is probably of greater interest to founders, namely, application of pulverised coal for annealing malleable cast iron, it is with regret that the authors are unable to publish any figures obtained from British practice, but the plant described below is actually in operation in France, and, subject to making due allowance for the difference in the quality of the coal obtainable in France and this country, it is thought that the description will be of interest.

Fig. 2 shows the furnace and type of equipment in operation. Before applying pulverised coal, the details of the operation were as follows:—*Width of oven*, 12 ft.; *length of oven*, 10 ft. 6 in.; *height from floor to curve of arch*, 6 ft. The ovens are lit, the doors sealed-up, brought up to heat and kept at a constant heat for 120 hours. Each oven holds 5 tons of castings. *Total actual consumption for* 120 *hours*, say, 7 tons of coal, costing 29s. per ton delivered.

The cans endured two heats only on account of the fact that, at one stage in the process, there was heavily reducing atmosphere, whilst later on there was a heavily oxidising atmosphere. Draught was regulated by the operation of the damper at the base of the chimney. First of all, the chimney was removed, and two lateral furnaces were used in order to arrange two gas-discharge ducts to take the gas to a main flue connecting up the various furnaces in the battery and leading to a brick chimney situated outside the building. A damper, which could be operated from the outside of the furnace, was fitted at each end of the flues above indicated, and this allowed the flow of the gases in the furnace to be correctly regulated.

A burner, similar to the one shown in Fig. 2, was fitted to the front of each of the furnaces, at such a distance from the hearth that the flame just passed well over the boxes containing the castings to be treated. The coal is brought to the burner by a screw-feeder and air by a pipe, fitted with a valve, which allows combustion to be regulated.

In the case of malleable cast iron, the re-heating operation is divided into three phases.

(1) *Raising the temperature.*—The approximate duration of this is 36 hrs., at the end of which time a temperature of 870 to 880 deg. should be registered. It will be obvious that the amount of coal to be consumed will vary according to the design of the furnace, radiation losses, tonnage of the castings to be treated, and also

the weight of the cast-iron annealing boxes. The dampers are so regulated that the furnace is well filled by the gases. In the case under discussion, the coal-feeder fed 60 to 66 lbs. of coal per hour to the burner.

(2) *Maintenance of the temperature.*—The duration of this period is 120 hrs., at a temperature fluctuating between 870 and 880 deg. C. The amount of coal consumed during this period depends above all upon a judicious handling of the dampers, so as to reduce to a minimum losses through the chimney and those due to radiation conditions in the walls of the furnace. In the case under discussion, the feeder supplied coal to the burner at the rate of about 20 to 22 lbs. of coal per hour.

(3) *Cooling.*—The duration of this stage is about 48 hrs. Cooling is split up into two phases, which depend mainly upon the conditions of manufacture. This cooling is carried out with the burners shut off, and can be dismissed from the question. Its underlying principles are as follows:—(1) The rate of cooling is 5 to 6 deg. per hr. to about 650 deg. when the dampers of the furnace are shut; (2) cooling is then made more rapid by opening the dampers, until the completion of the operation.

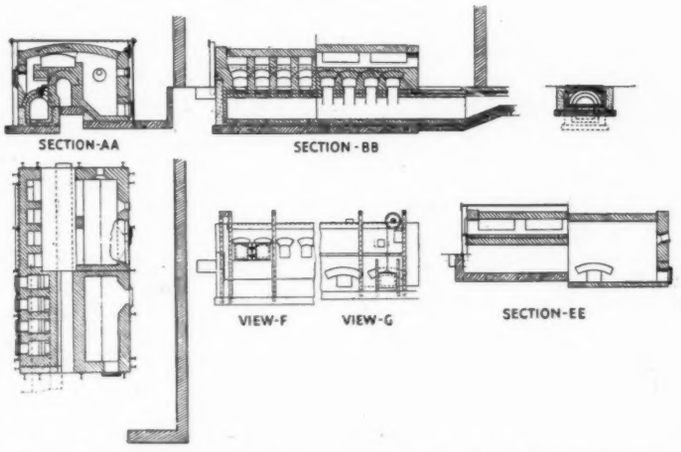


FIG. 1.—A REHEATING FURNACE FIRED BY PULVERISED FUEL, INSTALLED AT THE WORKS OF MESSRS. EDWARD SMITH, LIMITED.

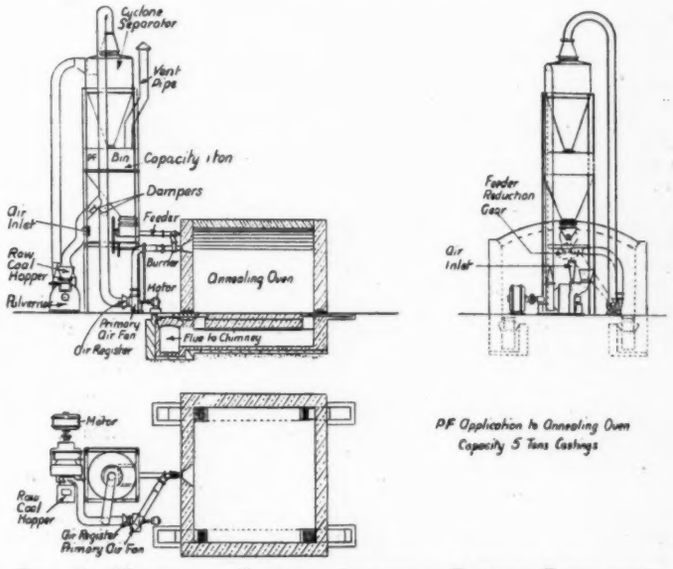


FIG. 2.—MALLEABLE CASTINGS ANNEALING FURNACE FIRED WITH PULVERISED FUEL.

(2) Temperature to be maintained under the same pressure conditions with a minimum amount of fuel.

(3) Strict observation of the fineness and moisture conditions of the pulverised coal used.

In malleable melting furnaces the coal requires drying down to about three-quarters of 1 per cent. moisture to prevent agglomeration of the particles as they go to the burners, as the addition of carbon and sulphur have been prevented by its proper drying.

In malleable annealing, with coal properly dried and pulverised to fineness as above, ratios of 4 to 5 to 1 are being secured, and the increased life of boxes is not the least saving.

Plate-Heating Furnaces

Messrs. Thomas Piggott & Company, Limited, of Birmingham, have applied pulverised fuel to two plate-heating furnaces, but, beyond the fact that the installations are both satisfactory, the authors have little or no knowledge of this plant. It is known, however, that they have found it necessary to use particularly dry fuel pulverised as fine as machines will permit.

Steel Melting Plants.

Open-hearth plants using pulverised coal are unknown in this country, but a number of them are in successful operation in America, and at this time the subject is being given marked consideration.

Owing to early difficulties with checkers and high furnace maintenance, in addition to the fact that open-hearth furnaces have been long ago brought to a high standard of efficiency, for gas and oil, there has been very little progress as to the number of plants changed to pulverised coal from other fuels. However, most of the early troubles have been overcome, and, whilst one plant has been in operation for six years, a large number of plants have been in operation for shorter periods of time. The elimination of expensive checkers and the ability to use low-grade, high-sulphur, high-ash coals in pulverised form, added to the increased tonnage possible, due to more uniform operation of furnaces, will make the change in fuel well worth while in many cases.

Frequently the difference in price between high-grade coal used for gas-producing operation and the screenings possible to use in pulverised form shows savings sufficient to pay for the installation in one year. Savings per gross ton of ingots produced in some cases run as high as 7s. 6d.

When pulverised coal was first used in open-hearth furnaces, it was found that the checkers were rapidly filling up with ash. It was believed at that time that this could not be prevented, and, therefore, arches were substituted for the checkers because of the greater space. The arches are placed about 18 in. apart, in rows, one above the other, with about 3 ft. between the rows. Slag pockets are equipped with removable structural steel boxes, which fill up in about 15 days. The time ordinarily required to pull two boxes and to get fuel in the furnace again is about 5 hrs.

The average analysis desired for coal suitable for pulverisation for open-hearth furnaces is about:—Volatile, 36 per cent.; fixed carbon, 52 per cent.; moisture, 1.25 per cent.; ash, 6 to 8 per cent.; and sulphur, under 1.25 per cent.

The operation of the open hearth does not present more difficulty than with producer gas, although it is not so simple as with oil.

Economies Effected.

A cold charge is used, and the time for charging is about 4 hrs., whilst a heat takes about 12 hrs.

The life of a furnace roof is about 200 heats, although the use of a flat suspended arch would probably increase this materially.

There is a milling plant on the central-station system, consisting of a battery of Raymond mills, coal being delivered to the furnace by means of a shooting tank, situated 450 ft. from the furnace. The coal required runs as low as 500 lbs. and as high as 600 lbs. per ton of ingots.

The wide variation is partly due to the grade of coal, partly to the charge, to the analysis required in the product, and a little to the age of the furnace, although the time from tap to tap varies less than was formerly thought possible.

The temperature maintained in the furnaces is essentially the same as that with producer gas.

Other applications of pulverised fuel which have had successful results are soaking pits, spelter furnaces and, in fact, almost any metallurgical process, particularly in the ferrous trade.

Puddling Furnaces.

The application of pulverised fuel to puddling furnaces is an excellent illustration of the advantages to be gained by this method of firing applied to metallurgical furnaces. The puddling

Results Obtained.

The weight of the castings to be treated is about 5 tons, and associated with this is a coal consumption of about 15 cwts. per ton of metal treated, these results being obtained with good-quality coal of calorific value of about 7,500 calories.

The boxes in which castings are stacked stand up much better, there being a difference of at least 5 to 1, whilst cases are reported where boxes have showed no signs of stress even after having been 15 times through the pulverised coal furnace, as compared with two or the maximum three times when the furnaces were hand fired.

It is highly important, however, that:—

(1) Very fine coal be used.

(2) Very efficient regulating dampers are supplied, so as to obtain exact regulation.

(3) The charging boxes be piled up very regularly on the hearth, and enough space left between them to ensure being well enveloped by the gases.

The results obtained require very close attention to firing operations, especially in regard to co-ordinating the rate of combustion with the operation of the gas-discharge registers, and it is apparent that the best way is to determine by experiment such rate of combustion as follows:—

(1) Temperature to be raised by about 20 deg. per hour using a minimum amount of fuel and the furnace remaining under slight pressure.

process consists of the conversion of pig or cast iron into wrought or malleable iron, and the temperatures required on the furnace hearth vary from about 500 deg. C. up to 1,500 deg. C., and, further, these temperature fluctuations are required with extreme rapidity.

In 1923, when the authors first applied pulverised fuel to puddling furnaces, the standard or accepted method of burning pulverised coal was employed, that is to say, a very large and deep combustion chamber of cathedral-like dimensions was erected, displacing the fire grate of the previously hand-fired furnaces. Into that massive edifice the pulverised coal was introduced with the whole of the air necessary for complete combustion, and the furnace hearth itself containing the metallic burden was heated by the products of combustion drawn over a fire bridge into the furnace proper. The temperature in the combustion chamber was obviously higher than that obtaining over the furnace hearth, because combustion was being actually completed before the furnace hearth was reached. The temperature, in fact, in the combustion chamber rose to such a point as to melt out completely the refractory lining of the combustion chamber. The unit therefore suffered from two obvious disadvantages, one of which was entirely disastrous. First of all, the life of the combustion chamber was limited to a few hours, and secondly, the development of the temperature was taking place at a point other than that where it was required. Various means of cooling the refractories of the combustion chamber were tried in hope of curing the major trouble, but obviously on such a small unit as a puddling furnace, which has an output of only about 3 cwts. of metal per hour, any frills in the design of the combustion chamber were commercially impossible owing to the capital cost of construction. It was necessary, therefore, completely to abandon all accepted practice in the firing of reverberatory furnaces with pulverised fuel, and to start afresh with a view to arranging the unit in such fashion that the combustion chamber should be at a low temperature, and that the maximum heat should be obtained over the working hearth of the furnace. This was eventually effected by reducing the combustion chamber in cubical content to a point not only less than that of the pulverised fuel-fired furnace, but considerably less even than that obtaining on the furnace as arranged for hand firing.

The whole combustion end of the furnace was, therefore, re-designed on the principle that, although the space required for the complete combustion of pulverised fuel is relatively large, nevertheless, if the pulverised coal was first gasified and the producer gas arising from that operation was burnt over the furnace hearth, such producer gas could be completely burnt over the hearth of the furnace, and in such burning the highest temperature could be developed at the point where it was required, namely, in contact with the metallic burden of the furnace.

To put the matter briefly, if the pulverised coal could first be gasified, it was obvious that no separate combustion chamber at all was required, but that the hearth of the furnace itself would serve as a combustion chamber for the development of the highest temperature. However, the gasification of pulverised coal is a very different proposition from that of solid or lump coal, which can be gasified in any commercial type of gas producer, whereas in the case of pulverised coal where the coal is introduced into the furnace at a more or less high rate of travel, an obvious difficulty that arose was the retention of the pulverised coal in the gasifying zone for an interval of time sufficient to turn it into producer gas. Such operation would require a long length of travel, and a chamber of considerable dimensions, but by experiment this disadvantage was overcome, as it was discovered that if the pulverised coal was introduced into a comparatively small chamber in such fashion that the stream of coal and primary air struck a bridge wall and recoiled into the oncoming stream, then a violent agitation or turbulent effect was set up in the gasifying zone, enabling the minute particles of coal to be retained in suspension therein, in contact with the deficiency of air for an interval of time sufficient to enable the whole of the coal to be turned into producer gas, the producer gas passing over the fire bridge and there coming into contact with a supply of secondary air (preferably pre-heated), sufficient to effect complete combustion of the gas over the working hearth of the furnace.

It is also found by observation that another great advantage has been obtained, inasmuch as the pulverised ash content of the coal was largely dropped in the gasifying chamber through the agitation taking place therein, and that only a very small percentage of the ash contained in the coal passed over the fire bridge into the furnace itself. These discoveries cured many troubles. First of all, the overall dimensions of the furnace were considerably reduced for the same output. Secondly, the life of the combustion chamber was prolonged indefinitely, owing to the fact that the temperature therein did not rise above 800 deg. C. The ash was collected before it reached the metal burden, and radiation losses were largely eliminated by reason of the very restricted dimensions of the primary chamber. In short, a revolution has been effected in the method of applying pulverised coal to a metallurgical furnace.

It is essential in this method of applying pulverised coal that the coal should be pulverised finely and uniformly, because if there are coarse particles of coal in the stream, these fall to the foot of the gas-producing chamber. It is true that these can then be gasified by the introduction of steam and air, but this means further capital cost and consumption of steam, both serious points on a small metallurgical furnace. The authors consider, therefore, that the coal preparation for metallurgical furnaces should, if possible, be effected in central mills rather than in unit mills, where there is a rather rapid deterioration in the fineness of pulverisation.

Pulverised Fuel Marketed.

Apart from this feature, the power and maintenance costs on central mills are very much lower than on unit mills, but, on the other hand, the comparatively small coal-user is unable to employ central mills as his coal demand is insufficient to warrant their installation. This difficulty is already overcome in certain foreign countries by organisations marketing coal in already pulverised form.

It has been suggested that in the firing of metallurgical reverberatory furnaces with pulverised fuel, no external combustion chamber at all need be employed; in fact, experiments have been made with a view to discharging the powdered coal directly on to the working hearth of the furnace. Theoretically, such application has merit, inasmuch as radiation losses are reduced owing to the elimination of the primary chamber. It has, however, been found that two disadvantages arise: first of all a cold zone exists in the furnace chamber immediately in front of the pulverised-fuel burner, owing to space being required for the development of the flame; and secondly, the ash content of the coal is distributed over the metal in the furnace.

The authors have shown the disadvantages of firing in a large combustion chamber on the one hand, and on the other hand, of firing directly on to a furnace hearth.

The gasification system described above eliminates the troubles and commercial drawbacks of both those methods. It has a further great advantage, that scaling losses of the metals are greatly reduced, owing to the fact that excess air is practically eliminated, and a slightly reducing atmosphere can be maintained over the hearth of the furnace.

Discussion.

Differences in British and Foreign Fuel.

MR. F. J. COOK said that pulverised-coal firing would be applied more widely in the foundry in the very near future, for the claims that could be put forward and proved with regard to it were such that no foundryman could ignore. He asked the authors to augment the Paper by stating what they considered the tendency would be in regard to the application of pulverised-coal firing to melting and annealing. Most of the applications of pulverised-fuel firing to foundry work had been applied in other countries than our own, and he had heard it stated that there was a considerable difference in the results obtained with some foreign coals and with British coals. He believed that the moisture content of British coals was a source of trouble, and if the authors had any data available as to the results obtained with coals from the various coalfields of this country in pulverised form, it would be of great help to foundrymen. Pulverised-fuel firing was being used very successfully in at least one instance in this country for melting and annealing. At first the application of the system had appeared to be almost hopeless, but he believed that was due largely to the difference in the nature of the coal used here as compared with that used abroad in a similar installation.

Difficulties in Slag Removal.

With regard to slag trouble, he said that that was one of the first snags in connection with steam generation; he believed that the first boiler which was fired with pulverised fuel had become one mass of rock in the course of about six weeks, and had had to be blasted and pulled down. We had got far beyond that stage, but he believed that trouble was likely to arise with the slag if pulverised fuel were used in a cupola; the fuel used would have a comparatively high sulphur-content, and he asked whether the sulphur would not so contaminate the slag that, when the metal fell through it, there would be considerable sulphur pick-up. He was not afraid of sulphur in quite large amounts, but there was a limit beyond which one could not go in this direction.

Powdered Fuel for Receivers.

MR. B. HIRD asked if pulverised-fuel firing could be used in a foundry for the purpose of maintaining the temperature of a quantity of metal in a receiver or for raising the temperature of the metal from that at which it was poured into the receiver to a higher temperature for use continuously on a casting plant. He also asked how far the fuel could be carried successfully from an existing plant to operate in a receiver such as he had referred to.

Feeding of Pulverisers.

MR. H. WINTERTON, junr., asked for further information with regard to the pulverisers. In Fig. 2 the pulveriser seemed to be so small as to represent an almost negligible part of the total outlay. Reference was made in the Paper to pulverising coal so that 98 per cent. would pass through a 100-mesh screen, and to an output of 4½ cwt. per hr. Presumably, if the process were to be economical, it would be necessary to have a hopper arrangement for feeding the coal in, because it would appear that if one had to feed a pulveriser by hand at the rate of 4½ cwts. per hr., the cost would be high. He also asked what type of pulveriser was referred to, and whether it worked at slow speed or high speed; if the latter, he suggested it would be necessary to pass the coal through a magnetic separator before pulverising, because no one received coal which did not contain tramp iron, and if it were not removed it would have a serious effect upon the pulveriser.

Powdered Fuel for Annealing Furnaces.

MR. J. W. GARDOM (Senior Vice-President, London Branch of the Institute) said it was sur-

prising, and somewhat disconcerting, to hear the authors state that the greatest factor of economy, when pulverised-fuel firing was adopted, was the difference between the price of high-grade coal and of the screenings which could be used in pulverised form. That might have been so a few years ago, but even metallurgists were getting sufficient commercialism knocked into them to recognise that as soon as there was a demand for anything the price of it would increase, and at the present time the difference in price is not great. In those circumstances, he suggested that the use of a pulverised-coal fired system would not be economical. He was interested particularly in the application of pulverised-coal firing to the annealing furnace. It must be remembered that when the furnace was fired with ordinary coal the fireman could leave it quite safely for a couple of hours or so, but it seemed to him that if it were fired with pulverised coal the mechanic would not be able to leave it for a moment; the fact that shifts could not be broken increases the number of pay-hours per day, and there is also the increased wage-rate between a fireman and a mechanic. There must be added to that extra cost another 2s. 6d. per ton of coal for pulverising. He did not agree with the authors' figures representing the costs of annealing in an ordinary coal-fired furnace. It was stated that 7 tons of coal were used to anneal 5 tons of malleable iron, but he himself—using the same times and figures as the authors—was able to anneal in one furnace with only 0.75 ton of coal per ton of castings. He need hardly say that that result was obtained with forced-draught, and that system had many advantages over pulverised-fuel firing. With regard to the two main types of pulverised-fuel systems, he disagreed with the authors' remarks as to the disadvantages of the unit system. It had the great advantage that its cost was lower than that of the bin-and-feeder system, and it was more flexible and could be changed from one furnace to another. The authors had mentioned as one of its disadvantages that the failure of the mill or motor would result in the furnace in which it was used becoming definitely out of action. He believed, however, that the present-day electric motor was very reliable. This being established leaves the suggestion by the authors that the mill breaks down, and he asked for confirmation of that.

Air-Separation and Drying Systems.

As to the statement that, with the unit system, pulverisation rapidly deteriorated from the first moment the mill was put into operation, he said he saw no reason why that should be so, if one used a fairly good pulveriser provided with an air-separation system. Again, it was stated that moisture had a serious effect; but that was so in both systems. There were many pulverisers on the market which would deal with coal containing up to 8 or 10 per cent. of moisture, and it was quite easy to reduce the moisture content to that extent by simple air-drying. Another disadvantage of the unit system, according to the authors, was that the plant was incapable of supplying a mixture of coal and air as accurately as that obtained with the central system. He pointed out, however, that the conveyance of the coal from the pulveriser was effected by means of primary air, and then secondary air was added, and he saw no reason why it should not be capable of adjustment at any time. With regard to the lay-out of the annealing furnace, he said that although the authors had given their reasons for not using a fire-box, he believed they were wrong. They had stated that the heat in the fire-box was so intense that it had melted away; yet they were going to put the burner straight into the furnace and burn the annealing boxes and pierce the work by the intense heat. He considered it better to have a fire-box, to place the burner in the fire-box and burn the coal there, and to adjust the dampers in order to draw the heat into the furnace. By such means one could obtain a more even annealing temperature throughout the whole of the oven.

Authors' Replies.

In reply to Mr. Cook, the application of pulverised coal to iron-melting cupolas has not so far, within the knowledge of the authors, been attempted, though a certain amount of experimental work has been carried out on blast furnaces in Germany, the results of which the authors are not familiar with. Pulverised fuel is highly successful when applied to melting and annealing furnaces, a fairly full description of the latter being contained in the Paper.

Effect of Different Coals.

There are very noticeable differences between foreign and British coals; even though the analyses appear the same, it is possible to have two coals of practically identical analyses, the one being "bright" coal and the other "dull" coal. These physical differences depend largely upon whether the main constituents of the coal are fusian, vitrain, clarian or durain. With the exception of lignite and one or two coals from Prussia, American and European coals are generally more friable than British coals, the result being lower power costs, cheaper maintenance and greater output from mills of supposedly similar capacity.

Slag and ash do present certain difficulties, and it never pays to buy coal purely on price without due regard to the calorific value, and therefore to the ash content. An excess of sulphur will contaminate liquid metal, and the sulphur content should therefore be kept down to under 1.25 per cent.

Referring to the points raised by Mr. Hird, no difficulty would be experienced in applying pulverised coal to metal mixers, and in the event of such an application being made, the powdered coal could be used either to maintain a certain fixed temperature or to raise the temperature as and when required. In this connection the pulverised coal could be carried about a thousand feet. If it were desired to convey the coal further it would be necessary to introduce a booster at this point, when the coal could be conveyed another thousand feet.

Coal-Handling Costs.

The application of pulverised coal certainly does not increase coal handling costs. On a large installation it would be possible to justify automatic coal handling plant, whilst on a small job employing one pulveriser, the hopper above the pulveriser could be made to hold, say, an hour's supply. It is customary to use magnetic separators, but these are not strictly necessary on unit mills, most of which are equipped with automatic separators working on the gravity and air suction principles.

Referring to Mr. Gardom's remarks, whilst it is true that there is no longer such a gap in price between lump coal and slack, there is still a difference sufficiently big to justify the use of pulverised coal. It is still possible in this country to buy coal as low as 11d. per ton at the pit head. The calorific value of the particular coal in question is 7,000 B.T.U.'s, and its economic value from a metallurgical process point of view is doubtful. On the other hand, no difficulty should be experienced in buying a slack at a price which would save at least 10s. per ton over the price of lump coal. Mr. Gardom also raised the question of a man standing by, and, as pointed out above, this is not necessary if the coal hopper is made of a sufficiently large capacity.

Bin and Feeder System.

The authors are unable to agree with Mr. Gardom's remarks on the subject of the unit system, and still adhere to the point of view that unless one is considering one furnace or boiler only, the bin and feeder system is the better proposition, and they offer the following reasons against the unit system for this decision:—

(1) The power consumption is equal to that required to drive the unit at no load plus a variable factor increasing with the output; (2) the capacity is affected by the character of the fuel and its moisture content; (3) the pulverised product varies in fineness with the output, the greater the output the coarser the product; (4) all have a maximum output beyond which, if the rate of feed is increased, the unit chokes and ceases to function; (5) all are subject to wear which, as it continues, results in a decrease of maximum capacity and in a coarser product at any given output, and (6) all have the characteristic, inherent in high-speed machines subjected to severe service, of being subject to breakdown without notice.

Combustion in the pulverised-fuel furnace is essentially an instantaneous process, so nearly so that for any momentary variation in the ratio of fuel to air entering the furnace there can be no compensation. Uniformity of air supply through the unit is easily obtained. Corresponding uniformity of coal feed, however, is most difficult, in fact well-night impossible, owing to variation in size and the effect of moisture content. To the extent that a variation in coal feed takes place, a loss in efficiency results. The loss due to unburned carbon in the flue dust increases with the rate of combustion in the furnace, a condition which is aggravated in the direct-fired system by the fact that the pulverisers are operating at their maximum output under such conditions, and therefore supply coal of the maximum coarseness. This result is further aggravated as the pulverising elements become worn.

In the discussion the point was raised that in foundry operations, presumably annealing operations, a firebox was necessary, otherwise the temperature would be too high in the furnace. The authors entirely agree as to the necessity, or at all events the desirableness of a firebox, though for rather different reasons.

The point is dealt with at some length commencing with the last paragraph on page 43. In fact the remainder of the Paper is indirectly an argument in favour of the firebox. The object of those pages being to describe the revolution which the authors have effected in the method of burning pulverised fuel for metallurgical operations.

Burning of Producer Gas.

The authors desire briefly to reiterate that the hitherto accepted practice of heating by means of pulverised fuel has been to heat the metal-carrying-furnace by means of the burnt gases arising from the complete combustion of pulverised coal in a combustion-chamber. Under the authors' system the metal burden is heated not by radiation from the burnt gas passing over or through the burden, but by the actual burning in the furnace of producer gas generated in a small primary chamber attached to and forming part of the structure of the furnace proper. It is well known that the range of temperature in a furnace employing producer gas can be made pretty well anything that is desired. In fact the authors specially refer to this aspect of the matter in the last paragraph on page 43. That is to say, the paragraph commencing "The application of pulverised fuel to puddling furnaces."

The authors' method is to employ the furnace proper as the combustion chamber, burning producer gas generated from pulverised fuel, and the standard method is to employ a separate and voluminous combustion chamber, where the pulverised fuel is completely burnt, and the burnt gases are subsequently employed to heat the metallic burden in the furnace.

Obviously of the two methods the authors' is much more economical, because by their method the heat value of the coal is employed in heating metal, and not brickwork.

XUM

Methods of Testing Cast Iron.*

By A. le Thomas and R. Bois.

[FRENCH EXCHANGE PAPER.]

(*Continued from page* 32.)

In a paper presented to a European Foundry Congress of 1927, Prof. Pisek, of the Czech Polytechnic at Brno, has published the result of a series of experiments with transverse tests on unmachined bars of different diameters varying from 15 to 40 mm., the distance between supports being shown in Table II (Group A indicates the German method and Group B the American):—

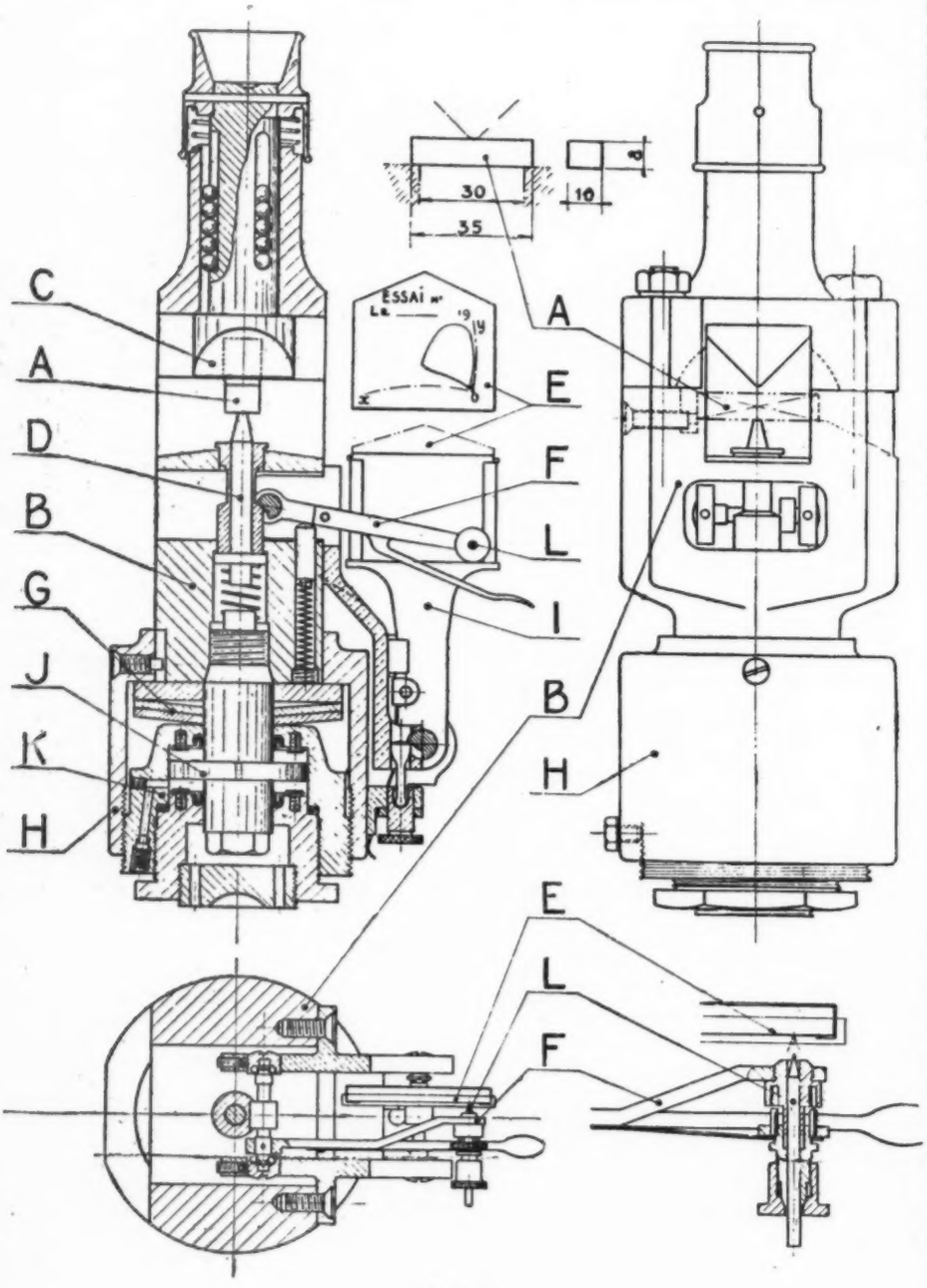


FIG. 7.

(A) BAR TO BE TESTED; (B) MAIN BODY; (C) CUTTER; (D) CENTRAL KEY FOR REGISTERING DEFLECTIONS; (E) SENSITIVE PAPER; (F) DEFLECTION REGISTRATION LEVER; (G) WASHERS FLATTENED IN PROPORTION TO LOADS; (I) LEVER CARRYING THE SENSITIVE PAPER, THE ROTATIONS OF WHICH ARE PROPORTIONATE TO THE LOADS; (J) HYDRAULIC DASH POT ABSORBING THE REBOUND AT THE MOMENT OF RUPTURE; (K) WATERTIGHT CYLINDER; (L) BRASS STYLUS.

For each of these test-pieces different methods were tried, the unmachined bars being cropped at both ends. The results obtained by the German and American methods gave almost parallel curves. The Frémont test was carried out on test-pieces taken from the lower part, at the centre or near the surface of the bar, and the course of the Frémont curve differs from the two others. From this Pisek concludes that the Frémont test is irregular.

The explanation of this apparent irregularity is, however, quite different. In the first place, the Frémont test-bars were taken from the cut-off ends, and therefore varied in soundness; in any case they differed slightly from the main body. Further, the unmachined bars transverse tested by the American and German methods were not homogeneous, their surface being certainly stronger than the centre, while the retention of the skin in the test also played a part in the values of the results obtained. On the other hand, the Frémont tests gave in place of this aggregate result the value of the transverse strength at a particular point in the test-bar—at one time the centre, at another the surface.

TABLE II.

Group *a*.		Group *b*.	
Diameter in mm.	Distance between supports.	Diameter in mm.	Distance between supports.
30	600	40	400
25	500	30	300
20	400	25	250
15	300	20	200

The tests, moreover, were carried out with a small Frémont machine, which, according to the author, showed considerable play. The Guillery apparatus is entirely beyond such criticism.

Various writers, Pearce in particular, have proposed the adoption of the modulus of rupture to express the results of the transverse test, and suggest the formula $R = \frac{PL}{4K}$ in which R is the breaking strength per unit of section surface, P the break-load, L the distance between supports, and K the modulus of rupture, a coefficient dependent on the shape and size of the test-bar. It must be observed that K cannot be calculated; it must be defined as the modulus of a test-bar of a given length and form of section, and it must be given an arbitrary value for that particular bar. In the case of variations of the first degree in the dimensions of the section—the shape of the latter remaining unchanged—it may be assumed that K is proportionate to the surface of the section, and $\frac{L}{4K}$ may be calculated in advance for dimensions approximating to those of the standard test-bar. Even if the transverse test has been carried out on a test-bar slightly too thick or too small, the value of R corresponding to an accurate test-piece can then be given.

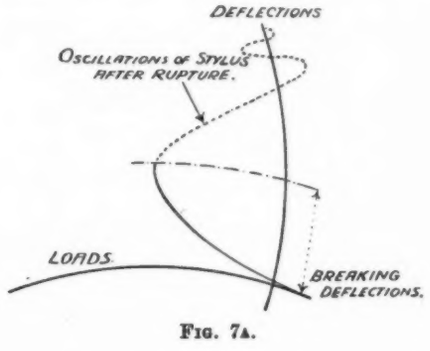


FIG. 7A.

This may be serviceable when the tests are made on unmachined bars, which are always more or less variable. But it is useless in the case of a Frémont transverse test on a test-bar machined to the required dimensions. The authors consider it simpler to represent the re-

* A Paper presented to the recent International Foundrymen's Congress.

sult of the test by the breaking load. The adoption of the modulus of rupture has also the disadvantage of referring the breaking strength to the unit of section surface, which is liable to make it be thought that this strength is proportionate to the section. Whatever Pearce may say, it is not desirable that "because the tensile test is expressed in kg. per mm². or its equivalents the transverse test shall be expressed in the same way."

Finally, the transverse test, which is the best test for cast iron, as it enables the resistance of the crystals to separation and the elasticity of their arrangement to be measured, ought to take

Fig. 8.

the first place among all other tests on account of its great simplicity, its certainty and its wealth of interpretation. The Guillery machine renders its execution simpler than the tensile test has ever been, and infinitely more accurate.

In regarding it as the test *par excellence* for cast iron, moreover, we are merely following the teaching of Monge in 1794 in the description of his "machine for ascertaining the strength of cast iron" ("Description of the Art of Making Cannons").

Hardness Test.

The authors cannot mention the hardness test without describing the very ingenious machine which they regularly use for testing small repe-

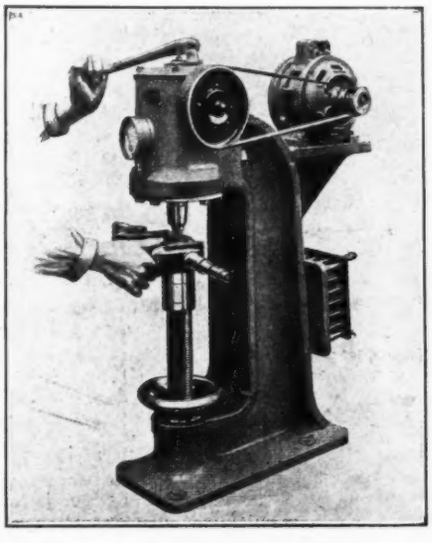


Fig. 9.

tition castings, the principle of which has been described by M. Guillery in a Paper to the Académie des Sciences on October 8, 1917. The object of his apparatus is to eliminate the influence of the duration of the test on the hardness number ascertained. The theoretical test consists in applying a pressure of 3,000 kg. for at least five minutes to the ball penetrating the metal under examination. It is practically impossible to observe this condition outside scientific laboratories where the value of time is not taken into account. If only ten seconds more or less accurately reckoned are taken, the result may contain errors amounting to some 8 per cent.

A very simple mechanical device enables this error to be eliminated. If the stress is suppressed immediately the pressure of 3,000 kg. is reached, the diameter of the impression will be too small by a quantity dD. If, on the other hand, instead of arresting the stress at 3,000 kg., it is continued to 3,000+dP, the diameter of the impression will be increased. For a reasonable value of dP the error resulting from the insufficient duration of the action of pressure may be exactly compensated. It gives practically the ratio: $\frac{d\text{P}}{3{,}000} = \frac{2d\text{D}}{\text{D}}$

It is possible to construct an apparatus in which the maximum pressure reached is automatically regulated by the speed with which the load is applied. Supposing that the pressure is transmitted to the ball by a hydraulic piston without friction, the water-tightness of which is ensured by rubber packing. The pressure exerted on the piston is limited by the raising of a valve consisting of a sphere S (Fig. 10) resting on a seat at an acute angle. The pressure required to raise the valve is then rigorously determined by the free section of the seating and by the stress exerted on the sphere. This stress is produced by springs, the tension of which can be varied at will by means of tension screws V, and the useful length by internal screw nuts E, which screw on to the spirals of the spring when at rest. This gives two independent variables for the regulation: the length and the tension of the spring. The stress opposing the lifting of the valve is dependent on the height of the lift, which increases the stretch and consequently the tension of the spring. The apparatus is regulated by trial and error, so as to have on any given metal the normal impression diameters for two loading speeds varying within the ratio of 1 to 30. The apparatus is simultaneously regulated for all intermediate speeds, as shown by the figures in Table III:—

Loading speed in: Kilos per sec.	100	200	300	600	1,000	1,500	3,000
Dia. of impression	4.38	4.37	4.40	4.39	4.40	4.39	4.39

This machine (Figs. 10 and 11) consists of a fixed frame provided with a ball, and the shear and static-transverse test appliances already mentioned are placed between the two balls of the machine. Thus arranged, it constitutes a small testing machine for cast iron, enabling the three fundamental tests—shear, static transverse and ball—to be carried out rapidly and economically, and therefore worthy of a place in all foundries, however small.

The ball test, unfortunately, is very frequently misused, and, as it can be made extremely easily and quickly, there is a tendency to deduce from it mechanical constants which it is incapable of giving. The ratios between hardness number, tensile strength, shear strength, compression strength and transverse strength, as given by a large number of writers, generally differ to some extent and give rise to sterile and tedious discussions. Portevin* very clearly gives the reason:—

"The compression test which gives the compressive strength and the hardness test which acts by localised compression are primarily affected by the combined-carbon content, and secondarily by the graphite, which behaves as an incompressible substance, whereas in the tensile test it constitutes so many fissures, as it were throughout the mass. It is natural, therefore, to expect parallel results as between shear strength and hardness number. As regards tensile strength, even presuming that the tests are carefully carried out, its value is affected by elongation: when it is very small as a result of graphite in plate form there is a premature rupture owing to parasitic bending and a fictitious reduction of tensile strength. According to the materials under examination, even with accurate tensile tests, a very different ratio between hardness number and tensile strength must be expected."

Nor is the ball test designed to measure "the machining hardness or the abrasive hardness," as Pearce appears to require. There is, in fact, a relationship as yet imperfectly defined between Brinell hardness and difficulty in machining.

Another criticism directed against the ball test by Pearce is that "the results are meaningless unless the position of the impression is clearly defined: a ferritic centre will give a lower Brinell hardness than a harder skin." This is precisely the great merit of this test, which enables the regions differing in composition to be ascertained with great accuracy, so that the homogeneity of a casting can be examined or castings produced in series compared. It is for this reason that the ball-test is, more than any other, a commercial test and specially indicated for the testing of castings.

In view of this examination of the different methods of testing which can be regarded as possible, it would appear that the shock and tensile tests ought to be eliminated, that the compression and torsion tests, while being definite in their indications, are not sufficiently simple for routine use, and that the shear, static-transverse and ball-tests must be regarded as the standard tests which enable the characteristics of a sample of iron to be perfectly determined. Apart from their scientific character, they have all the qualities required in any commercial test: they are economical, accurate and rapid, and since the production of the Guillery machine, which makes it so easy to carry them out, it would seem that no further criticism can henceforth be directed against them.

It must be understood that only mechanical tests are being considered at present, which it

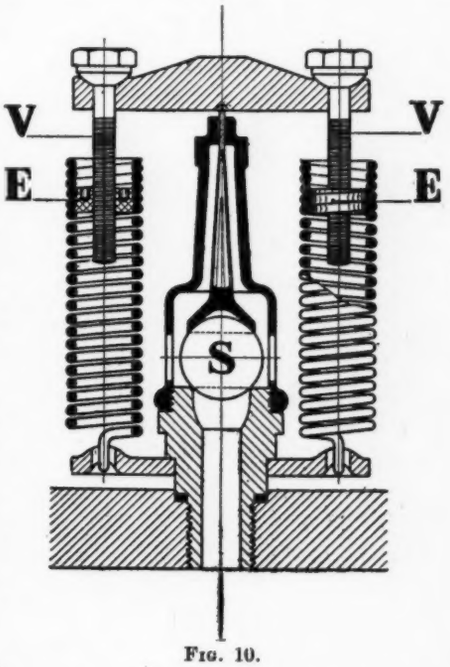


Fig. 10.

is very desirable to supplement with micrographic examination and chemical analyses such as the authors have already had occasion to discuss at length in a Paper presented to the

Fifth French Foundry Congress under the title of "Personal Experiences of the Application of the New Methods of Testing Cast Iron."

Effects of the Individuality derived by Castings from their Thermal History on Methods of Testing them.

In the first part of this Paper the effects of the heterogeneity of cast iron and its special characteristics on the choice of the tests designed to interpret it were examined. It is now proposed to discuss the effects due to the individuality which every casting derives from its thermal history in order logically to utilise the measuring methods described for the purpose of determining the mechanical properties of the casting, which is, after all, the end to be attained. How is the problem to be stated? There are available shear, static-transverse and ball-testing apparatus which give an exact idea of the relative mechanical value of a certain number of samples of cast iron—bars, for instance, for the sake of precision. From the classification obtained, it is logical to conclude that machines entirely constructed of metal identical with that of each sample will be classified when in use in the same order. In other words, the figure resulting from the test carried out on the sample will enable the relative value of the casting when in use to be predicted: the test will enable the characteristics of the casting to be determined.

All this assumes, however, that the casting in question is composed of metal identical with that of the sample tested, and identity means the same chemical composition and the same crystalline structure. But, for any given chemical constitution, this structure is dependent upon the predominance during the course of cooling following the pouring of either the stable or the metastable system of the iron-carbon combination. The authors have already had occasion to point out the influence of the various constituents which then arise upon the mechanical properties —graphite, ferrite, cementite and pearlite—and shall not revert to them again here. Be it noted merely that according to their relative proportions the strength will vary considerably, as also elasticity, fragility, hardness and machinability. The law of cooling which governs the crystalline structure, and consequently the mechanical properties, is dependent upon no less than twelve factors, some of which in particular are inherent in the casting, such as wall-thickness and distribution of the masses in the casting, others being peculiar to the mould, such as temperature and humidity of the sand, while yet others are inherent in the external conditions, such as the surrounding temperature. It follows in the first place that two identical castings poured from the same metal taken at the same temperature may be subject to different laws of cooling and may therefore have a different crystalline structure; and also that the different parts of a single casting may undergo the same cooling only exceptionally and may therefore have different mechanical properties. Even the chemical composition will not be uniform, as the solubility of the different impurities such as sulphur and phosphorus and the gases in the alloy will vary with the more or less advanced state of solidification, and as their concentration will be greater in the parts which are the last to solidify. It should also be noted that to these numerous causes of heterogeneity must be added the influence of internal stresses which, moreover, are the more dangerous, as they are less understood and are impossible to discover and measure.

After all, the problem to be solved is to foretell the mechanical properties and the behaviour in use of a casting of varying chemical composition and heterogeneous crystalline structure, that is to say, mechanical properties varying at its different points and, finally, subject to unknown and variable internal stresses.

Method for Frémont Tests.

Application of Frémont Tests to Castings.

Be it noted, in the first place, in order to simplify the question that chemical heterogeneity is not very apparent and may be disregarded in the initial examination. Internal stresses will also be left out of consideration, although they are of considerable importance and their effects are frequently unexpected, because up to the present there has been no means of studying them, and all that is done is to try to reduce them by a judicious choice of design and thickness and, possibly, by suitable heat-treatment.

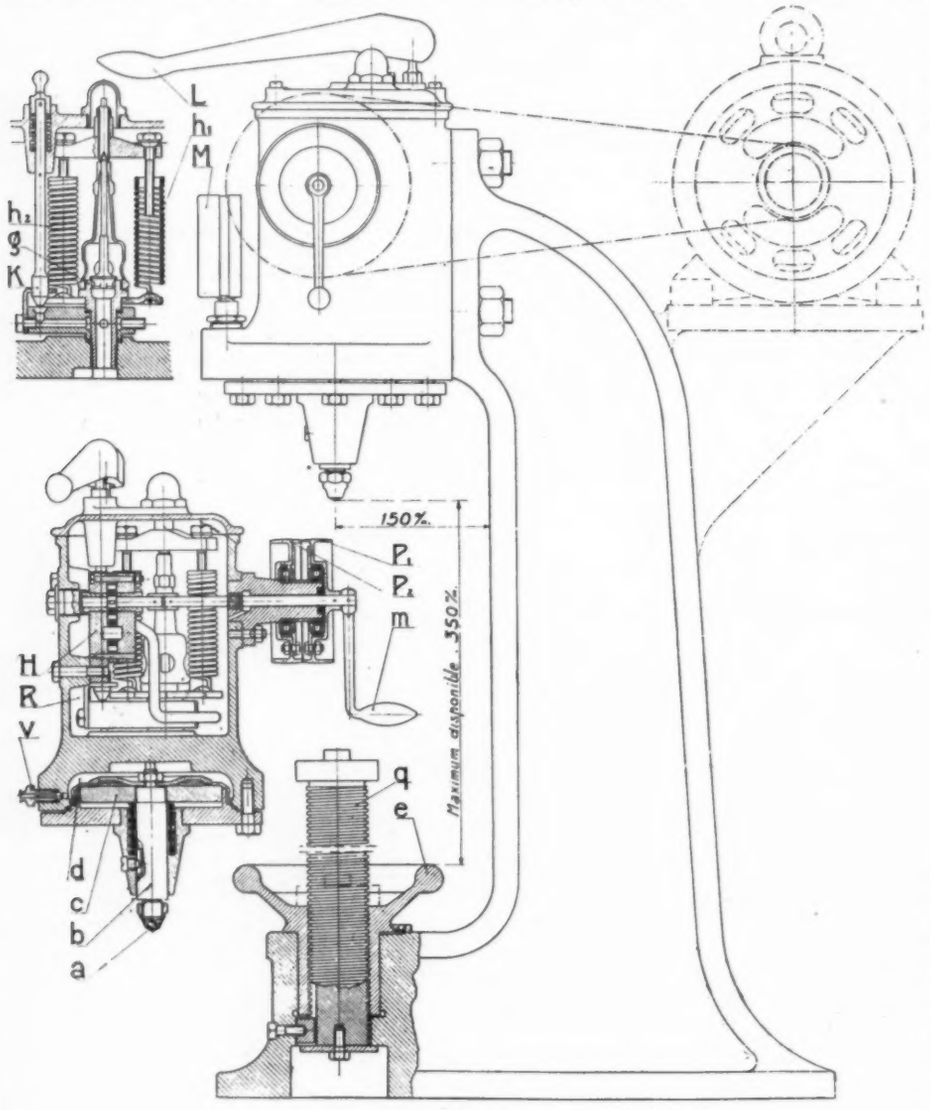


Fig. 11.

(a) Testing Ball; (b) Rod integral with Piston c; (c) Piston; (d) Chamber filled with Glycerine; (H) Geared Pump; (R) Glycerine Tank; (K) Valve-Closing Chamber d or Connecting it with the Tank R; (L) Control Lever of Valve; (g) Hardened Steel Valve Seat; (h_1-h_2) Regulating Springs; (M) Manometer controlling Pressure in Glycerine Chamber.

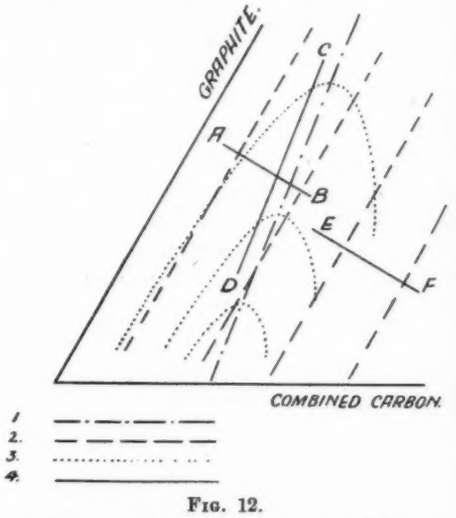
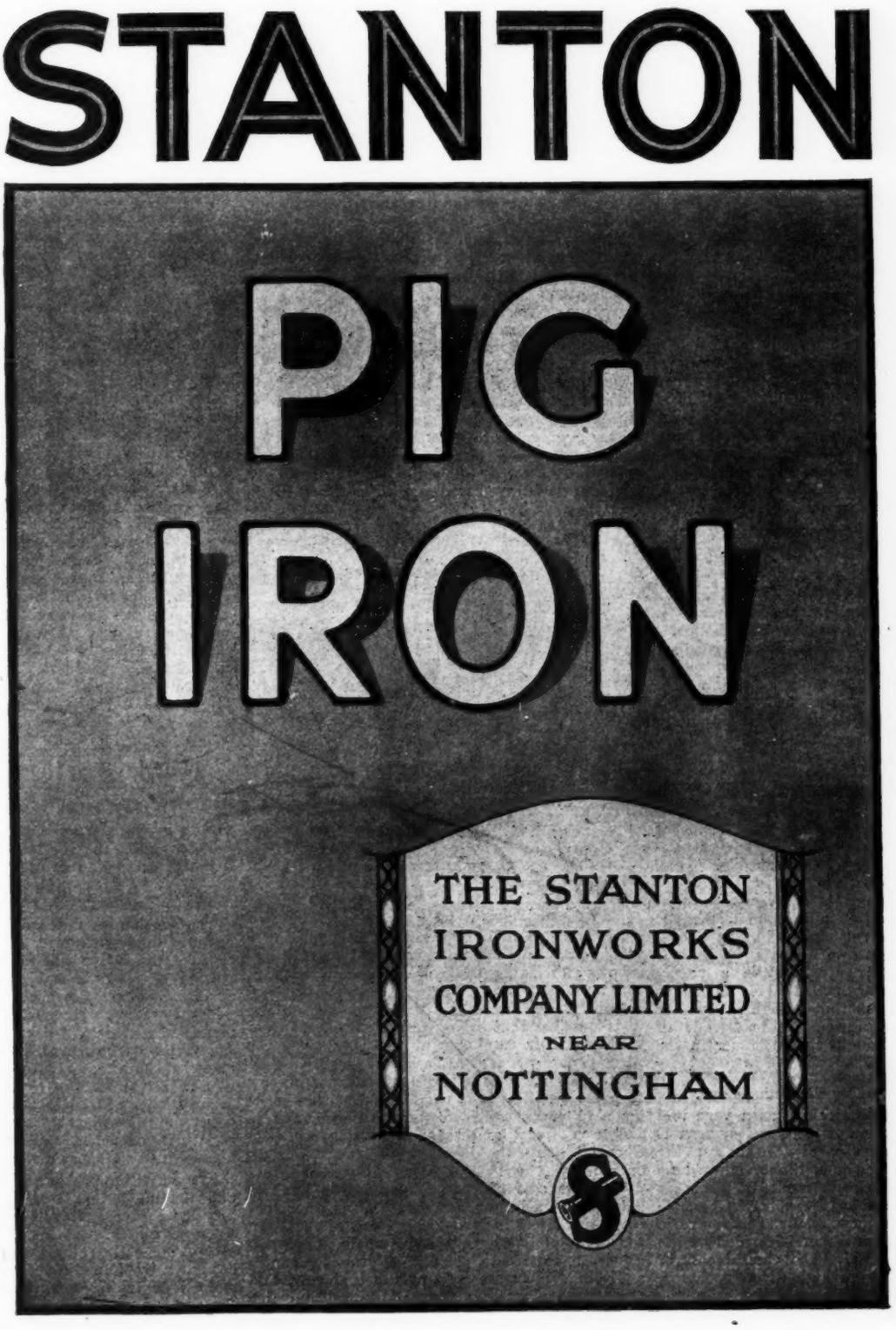


Fig. 12.

(1) Pearlitic Cast Iron; (2) Equal Hardness Curves; (3) Equal Tensile Strength Curves; (4) Along A-B, Hardness increases, Tensile Strength decreases; Along C-D, Hardness is constant, Tensile Strength increases; Along E-F, Hardness increases, Tensile Strength decreases.

Since it is not possible to make a casting of a well-defined material, which can be tested separately in order to know it accurately, it is proposed to reverse the problem and take from a finished casting a sample capable of defining the properties of the material constituting it. It must be noted, however, that by so doing information will only be available as to that part of the casting from which the sample is taken or a small portion in its vicinity. One may then consider the application of this method

(*Continued on page 50.*)


STANTON
PIG
IRON
THE STANTON
IRONWORKS
COMPANY LIMITED
NEAR
NOTTINGHAM

Buying Electric Power.

By "Kilowatt."

In dealing with the various factors governing the purchase of electric power from the local supply authority for driving foundry plant as against private generation, one if often bewildered by the existence of varying tariffs framed by the supply undertakings. With a view to assisting the power user to arrive at an approximate estimate of his power bill, where a supply is taken from the mains it is proposed to outline the systems of charges adopted by the supply companies.

Systems of Charging.

Electrical work done by a kilowatt-hour represents the same amount of work done whatever the conditions may be under which the energy is used. But while this work-value of the standard unit of electrical energy is unalterable, the cost varies.

A study of the rates charged by electricity supply undertakings reveals the existence of different scales of charges. While some undertakings charge an all-round "flat rate" of so much per kilowatt-hour consumed, others adopt a "maximum demand" system. For very large users, power may be sold in bulk, with a guarantee of a certain large quantity as a minimum. The cause of this variation in charges may at first seem somewhat perplexing, as it might be imagined that the cost of central-station generation should be practically the same throughout the country.

Importance of Load-Factor.

The aim of the central station engineer is to increase the output of his plant, though not at the expense of increasing capital cost or labour charges. The additional load will then reduce the cost of both these items per unit sold. The output of any power station is of necessity a variable quantity, the demand varying from hour to hour. This introduces the question of load-factor, which has an important effect on generating costs.

Load-factor is defined as the ratio which the average demand of the year bears to the maximum demand for the same period. A low load-factor, therefore, involves the use of relatively large plant operating at light and inefficient loads; but with a high load-factor all the elements of expense that enter into the production of power are at a minimum. Except in the case of a central station having a considerable factory power-load, this load-factor seldom exceeds 28 per cent., while a purely lighting load may mean a load-factor as low as 12 per cent. It follows that a high load-factor means lower generating costs, the benefit of which can be passed on to the consumer in the form of cheaper power.

Other Factors governing Generating Costs.

Another consideration, which has a very real influence upon the price of electrical energy, is the supply to a number of consumers, the character of whose demands differ, and whose periods of maximum loads occur at different times. This is known as the central station's "diversity-factor," which is defined as the ratio of the sum of maximum demands divided by the actual maximum demand. The capital cost of a station is reduced by a high diversity-factor, and a considerable difference is made in the standing charges which are charged against each customer.

A further important point that may be made in connection with the public supply of electricity is the increasing number of consumers, which must eventually cheapen the supply, and a foundry situated in a growing industrial centre, where a supply of electricity is available from the mains, may reasonably assume that the present cost of such power will be reduced in the future—a fact which may have an important bearing on the selection of the source of power.

With regard to the actual systems of charges, the principle adopted by many supply undertakings is a fixed sum per kilowatt of maximum demand, plus an additional charge of so much per unit actually supplied. This is known as the "maximum demand" system.

"Maximum Demand" System.

The maximum demand actually made in kilowatts at any time during the year is measured, and a charge of, say, £2 per kilowatt of maximum demand per quarter, is made, plus 0.5d. per unit, as registered by meter. Thus, the management of a foundry contemplating the purchase of electrical energy, must ascertain its maximum demand—which literally would be the sum of the powers of all the individual motors. In practice, however, it rarely happens that every motor in the foundry is running at the same time, and the maximum demand is more likely to represent two-thirds, or even one-half, of the aggregate brake-horse-power of the motors installed.

For instance, in two foundries using, say, 50 units per day, the energy consumption of the first, A, may be:—

7 kilowatts	for 2 hours	=	14 units.
4 ,,	,, 4 ,,	=	16 ,,
40 ,,	,, ½ hour	=	20 ,,
	Total	=	50 units.

Here it will be seen that the maximum demand is 40 kilowatts. In the case of the second foundry, B, who has made an effort to keep his *average* load as high as possible, and his maximum load low, his 50 units may be accounted for as follows:—

4 kilowatts	for 4 hours	=	16 units.
5 ,,	,, 2 ,,	=	10 ,,
6 ,,	,, 4 ,,	=	24 ,,
	Total	=	50 units.

In this case the maximum demand does not exceed 6 kilowatts.

Effect of Coal Prices.

Obviously, the best load to cultivate, from a supply authority's point of view, is that of "B," because, assuming a total of 1,000 consumers, the total plant capacity need not exceed 6,000 kilowatts. In the case of "A," however, where it is possible that 1,000 consumers may be demanding their maximum at the same time, the plant capacity must not be less than 40,000 kilowatts. In considering these rates it is necessary to point out that it is usual for provision to be made in power contracts for the rise or fall in the price of coal, and where this is done a "Coal Clause" may be inserted to the following effect:—

"If the cost of coal delivered into bunkers at the generating station exceeds (20s.) per ton, there will be an increase on the cost of coal. In the event of any change being made under this clause, a certificate granted by the company's auditors will be accepted as the coal cost, and the extras, if any, will be made up and payable quarterly."

Where a foundry is operating on the "maximum demand" basis, it is important to remember that any increase in the maximum load will have a material effect on the annual bill. For example, if the motors in a foundry giving an aggregate demand of 100 kilowatts were overloaded 20 per cent. for an hour, the effect would be to increase the maximum demand from 100 kilowatts to 120 kilowatts, which, at the rate of £8 per kilowatt, would mean an addition of £160 to the annual bill, plus the charge for extra units consumed. Care should, therefore, be exercised to prevent unnecessary simultaneous overloading of the system. Another method of charging adopted by the supply companies is that known as the "flat rate," whereby the consumer pays an all-round rate of so much per unit consumed, irrespective of his maximum demand.

Variation of Electricity Charges.

Visiting various factories up and down the country, one hears from time to time complaints from power users regarding the tendency towards complications in the tariffs by electricity supply undertakings. It is alleged that one cannot be sure what they will be called upon to pay unless a flat rate charging system is in force. Admittedly, the flat rate is simple, but it can hardly be suggested that engineers know so little of their plant that its maximum load is unknown, and, therefore, they cannot estimate charges on a load-factor or two-part tariff. An absolutely equitable tariff for every individual power user is impossible of attainment. If such a system were put in force on any one particular day, the arrival of a new consumer next morning with a demand varying from the average fixed for the existing consumers is immediately upset—thus a constant state of flux follows. Again, changes in the station's diversity-factor, by reason of a consumer's peak load changing the time of day, will alter the station's maximum load, and this, in turn, would affect the kilowatt charge.

It will, therefore, be seen that the framing of a strictly equitable tariff for each consumer is an impossible task. The best that can be achieved is an approximate average distribution of charges—a two-part tariff approaching as near as possible the desired solution. More elaborate tariffs certainly tend towards dissatisfaction on the part of the consumer, and it would appear that a simple maximum load charge, embodying the usual coal and power-factor clauses, should present no difficulty in estimating the cost of running plant electrically.

Methods of Testing Cast Iron.

(*Continued from page* 48.)

to the problem posed and to the more general problem of finding the best parameters to adopt for the production of particular castings from the point of view of design, thickness, shape, method of casting, etc.

The problem of determining the properties of castings, and, therefore, the problem of inspection by the buyer will be solved as follows:—Among the points subjected to the greatest mechanical stress, several taken at random, or selected among those which always turn out weakest in casting, will be examined. The casting will thus be sounded at the weakest parts amongst those required to show a good strength figure. If the tests in regard to these are satisfactory, this will constitute a guarantee to the buyer, and it will not prevent the testing points from being sufficiently distributed to give a true idea of the casting as a whole.

As regards the problem of improving the design and the method of casting which concern the foundry engineer, it will be already half-solved, since he will have at his disposal a certain and easy means of knowing the quality of the casting designed by him in its various parts. The method of taking test-pieces from the casting, therefore, appears to the authors completely to solve the question of testing engineering castings. Before examining and refuting the criticisms that have been directed against it, showing why the other methods put forward are worthless, and submitting that it is the only test of any value, it is proposed to describe in detail how the test is carried out in practice.

(*To be continued.*)

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PNEUMATIC TOOLS

M-C. 84

Trade Talk.

DURING THE past six months the Dumbarton works of Messrs. Babcock & Wilcox, Limited, have made contributions totalling £188 to a number of infirmaries.

MESSRS. REDPATH, BROWN & COMPANY, LIMITED, Edinburgh, have received an order for the steel work for new locomotive workshops at Aba Zaabal on a tender of £74,178.

LOUDON BROS., LIMITED, of Johnstone, have received an order from Messrs. Burmeister & Wain, Copenhagen, for one of their patent planing machines for large Diesel-engine work.

A PROBABLE RECORD for this country in the discharge of iron ore was made at Cargo Fleet Iron Works, Middlesbrough, this week, when 2,572 tons of Swedish ore were unloaded from the s.s. "Kaprino" in 7¼ hours. This is at the rate of 355 tons per hour.

THE FIRST DESTROYER built on the Tyne since the war was launched recently by Messrs. R. & W. Hawthorn, Leslie & Company, Limited, Hebburn. The vessel is H.M.S. "Active," with a displacement of 1,330 tons. A sister ship will be launched on July 26, and the firm has two other destroyers on order.

MESSRS. BUTTERLEY COMPANY, LIMITED, of Butterley Works, Derby, have secured a contract for 25 steel bridges, to be erected for the Mid-Nottinghamshire Joint Railways. Mr. F. T. Smedley, manager of the department, has stated that an additional 100 men will be required for six or eight months.

AFTER LENGTHY negotiations between the works management of the Consett Iron Company, Limited, and the men's representatives with regard to piece rates in the angle mills, a settlement has been reached. The new rates range from 1d. to 1½d. per ton, according to grade, over 15 tons per shift. Should the output for the shift fall below 15 tons, the men can still claim their datal wage.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Springburn, Glasgow, have secured a contract for 15 pairs of locomotive (duplicate) cylinders for the Indian State Railways. The cylinders are to be adapted for "Lentz" poppet valves, in place of the usual slide or piston valves. The firm have also received an order for six pairs of locomotive (duplicate) cylinders for the Royal State Railways of Siam.

THE ZINC PRODUCERS of the United Kingdom, Germany, Silesia, France, Belgium, Canada and Mexico have just held a meeting at Ostend. A communique issued after the meeting states that the European, Canadian and Mexican zinc producers have decided to reduce production by 10 per cent., instead of 5 per cent., up to the end of the current year. The meeting to decide on the 1930 rate of production will be held later.

THE CANADIAN PACIFIC RAILWAY COMPANY have placed an order with Messrs. William Denny & Brothers, Limited, Dumbarton, for a vessel for their Bay of Fundy service between Digby and St. John. The vessel will be about 330 ft. long and will have a speed of 19 knots. The machinery will consist of twin-screw geared turbines, steam being supplied by water-tube boilers, while a Scotch-type boiler will supply steam for auxiliary purposes.

A DEPUTATION OF the Lanarkshire Members of Parliament, along with Mr. James Walker, representing the Confederation of Steel Trades, has interviewed the Minister of Labour, Miss Bondfield, with regard to the conditions of unemployment and distress arising out of the closing down of Mossend Steel Works. The Minister made special inquiries as to the proportion of the idle men who could not expect re-employment locally, and promised that the whole of the circumstances would receive careful consideration.

A NOTE OF OPTIMISM as regards the prospects of the iron and steel trade was struck by Mr. Thomas McKenna, general secretary of the National Union of Blastfurnacemen, Ore Miners, Coke Workers and Kindred Trades, in his report to the annual conference of the Union. He expressed his belief that the pig-iron trade was advancing into its natural state for the first time since the conclusion of the war, and stated that there was a sureness and stability about the present circumstances of the industry which previously had been absent.

SEVERAL STEELWORKS in the Motherwell district are to close for only one week during the Fair holidays instead of a fortnight as has been the rule. It is many years since the holidays were so curtailed, and the local steelworks are experiencing a boom in trade at present, which promises to last for some time. At Messrs. Stewarts & Lloyds, Limited, Clydesdale Works, Mossend, men have been working during the recent week-ends, overtaking the arrears of work. There is a hopeful feeling in the district that Beardmore's Mossend Steel Works, which have been closed for over a year, may make an early resumption.

THE GERMAN UNITED STEELWORKS (Vereinigte Stahlwerke) have issued their report for the third quarter of the business year 1928-1929 (April to June, 1929). This shows a turnover of £20,377,500, as compared with £17,605,500 in the second quarter. Home sales improved from £11,106,500 to £12,413,500, and foreign sales from £6,499,000 to £7,964,000. The turnover for the first three quarters of the business year amounted to £51,733,500, a decrease of £1,436,000 as compared with the corresponding period of the previous year. While the home turnover in the three quarters declined from £36,109,500 to £32,554,500, the foreign turnover increased from £17,060,000 to £19,179,000. Orders in hand at the end of June equalled 100 per cent. of the monthly average during the previous business year.

THE BLYTHSWOOD SHIPBUILDING COMPANY, LIMITED, Scotstoun, Glasgow, have launched the second of the two twin-screw motor-ships which they have built for the Prince Line, Limited. This vessel, the "Siamese Prince," is intended for trading between New York and the Far East, and is 460 ft. long, 60 ft. in breadth, and 42 ft. 6 in. deep. She has three decks and is specially equipped for the rapid handling of cargo, having 19 powerful electric winches controlled from contactors in separate houses. The steering gear is of the electric-hydraulic type. The main machinery will be supplied by Messrs. Richardsons, Westgarth & Company, Limited, West Hartlepool, and consists of two sets of engines of the Doxford opposed-piston type, each having four cylinders of ample power to give the vessel a service speed of 14½ knots.

MESSRS. ALEXANDER STEPHEN & SONS, LIMITED, Linthouse, Glasgow, have, it is stated, secured the following orders:—A twin-screw steamer for the Great Western Railway Company, to be used for service between Fishguard and Rosslare; the vessel will be 280 ft. long by 40 ft. beam, and will be propelled by single reduction-geared turbines; a contract to construct a single-screw tug to the order of the Australasian United Steam Navigation Company, Limited, identical with the "Forceful," which was built by Messrs. Stephen for the same owners in 1925; the construction of a large private yacht, of approximately 2,200 Thames tonnage, to be propelled by triple-expansion engines; and a large fruit steamer for Messrs. Elders & Fyffes, Limited, the vessel to be similar to the s.s. "Nicoya."

ON JULY 6 Mr. E. A. Ebblewhite, Master of the Worshipful Company of Ironmongers, formally handed over to the University of Sheffield the new department for research on the cold-working of steel and other ferrous metals. The creation of this important addition to the equipment of the Applied Science Department of Sheffield University has been made possible through the generosity of the Ironmongers' Company and of a group of local firms in the wire-drawing and cold-rolling industry. The Ironmongers' Company have promised to provide the sum of £800 annually for seven years, to maintain a research fellowship and two scholarships. Sheffield firms have jointly contributed through the Cutlers' Company of Hallamshire the cost of the apparatus installed in the laboratory set apart by the University for the new research work. The laboratory is equipped with a 10-in. cold-rolling mill, a bench for drawing wire and rods, and all other necessary plant.

IN CONNECTION with the purchase by the Frodingham Iron & Steel Company, Limited, of the assets of the Yorkshire Iron & Coal Company, Limited, Leeds, it is ascertained that the major portion of the properties has been sold by the Frodingham Company to Thos. W. Ward, Limited, of Sheffield, whose purchase includes the blast furnaces and works near Ardsley, the colliery near Morley, and a large acreage of land used for agricultural and industrial purposes. It is thought that arrangements will probably be made to reconstruct those sections of the plant which are likely to become successful industrial propositions, and to dismantle the obsolete portions. The business, commenced about 1866, was formerly owned by the West Yorkshire Iron & Coal Company, Limited. The closing of the works added considerably to the ranks of the local unemployed, and hopes are entertained that the rearrangements will absorb many of those still out of work.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Electric Carburising Furnaces.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We have noticed in your issue of June 27 a statement to the effect that the Birmingham Electric Furnaces, Limited, are to instal an electric furnace for carburising which has a usable hearth 9 ft. long by 5 ft. wide, and that it is thought that this furnace will be the largest electric carburising furnace in this country.

This is not the case, as rather over a year ago we installed a furnace used for carburising with two heating chambers, each 8 ft. 6 in. long by 7 ft. 6 in. wide, which, as you will see, is considerably larger than the furnace referred to in your journal.

The furnace was installed at the Coventry works of the Daimler Company, Limited.—Yours, etc.,

W. S. GIFFORD.

Electric Furnace Company, Limited,
17, Victoria Street, London, S.W.1.

New Companies.

Ayling & Company (Brassfounders), Limited, 63, Charlotte Street, London, W.—Capital £1,500. Directors: A. C. Ayling and Mrs. F. M. Ayling.

Chromium Platers (Liverpool), Limited, 4, Harrington Street, Liverpool.—Capital £2,000 in £1 shares. Directors: J. L. B. Hands, A. E. Christie and Mrs. J. E. Hands.

Jones Engineering Company, Limited, 92, Ryland Road, Edgbaston, Birmingham.—Capital £25,000. Directors: J. Jones (managing director and chairman), H. W. Wolton and A. Jones.

Sir W. G. Armstrong, Whitworth & Company (Engineers), Limited.—Capital £1,500,000 in £1 shares, to take over the business of general engineers carried on at Scotswood and Gateshead by Sir W. G. Armstrong, Whitworth & Company, Limited.

Sir W. G. Armstrong, Whitworth & Company (Shipbuilders), Limited.—Capital £750,000 in £1 shares, to take over the business of shipbuilders carried on at the Dobson, Walker, and Tyne Iron Shipyards, by Sir W. G. Armstrong, Whitworth & Company, Limited.

A. W. Second Stock Trust, Limited, 27, Old Broad Street, London, E.C.2.—Capital £700,017 in £1 shares, to carry on the business of an investment and trust company and to acquire from Sir W. G. Armstrong, Whitworth & Company, Limited, a part of its undertaking comprising certain securities and assets of the company. Directors: J. H. C. Johnston, T. E. Baring, and Sir Edward J. Reid.

Personal.

SIR ROBERT HADFIELD, BT., has been the recipient of a presentation from the managers and foremen of the Sheffield works of Messrs. Hadfields, Limited, in commemoration of his 70th birthday. The presentation took the form of an illuminated address and a book containing the signatures of over 130 contributors.

Wills.

BYASS, SIR S. H., BT., of Messrs. R. B. Byass & Company, Limited, Margam and Mansel Tinplate Works, Llanelly £101,570

Obituary.

MR. BERNARD GAMBLE, of Messrs. Moss & Gamble Bros., Limited, Sheffield, died on Thursday, July 4, aged 61.

MR. WORCESTER REED WARNER, a pioneer and distinguished leader in the machine-tool industry, formerly president of the Warner & Swasey Company, Cleveland, U.S.A., died at Eisenach, Germany, on June 25, at the age of 83 years. He had been travelling with his family in Europe since early in May.

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We don't sell foreign castings and deprive you of work. We support British Institutions and trade and technical associations. We live here and pay British rates and taxes. We help to buy your output.

We don't ask for orders for 500-ton lots (payment against B/L), we sell in truck loads and wait for our money—sometimes three or four months (sometimes we never get it at all). We are always here at the end of a wire for advice, help or support. If you receive from us any goods you don't like—send them back.

We give prompt delivery of Yorkshire Sand and every ton lot of it you buy finds work for Englishmen and Scotsmen and helps to improve your own business by circulating more money in the country, and reducing the amount sent abroad for needless foreign purchases.—Think it over and you will see we are right.

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—As indicated in recent reports, the position in the Cleveland iron market continues extremely difficult to summarise in the brief limits of space at disposal, but, at all events, signs are not lacking that the extended period of scarcity of supplies is now claiming much more active attention on the part of producers in the district, and that local furnaces are again prepared to accept orders. It is admitted that, as makers have previously affirmed, they are unable to accept any more orders for delivery over the third quarter of the year, but they have intimated that they are now willing to negotiate sales at current rates for delivery over the last three months of 1929. The term current rates indicates a minimum of 72s. 6d. per ton for No. 3 Cleveland G.M.B., 75s. for No. 1 foundry iron, 71s. 6d. for No. 4 foundry, and 71s. for No. 4 forge. These figures are 4s. in advance of the minimum ruling when the last sales were made by makers towards the end of April, but since that date coke has advanced about 2s. 6d. per ton, and it is claimed that the advance in selling prices no more than covers the rise in the cost of raw material.

The demand for East Coast hematite is well maintained, both for home and overseas consumption, buyers being convinced that an advance in price is imminent, having recently placed substantial contracts up to the end of the year. As a matter of fact a small advance has been made this week, sellers of mixed numbers now quoting 75s., and for No. 1 quality at 75s. 6d. On the North-West coast, Bessemer mixed numbers are still quoted at 75s. per ton at works.

LANCASHIRE.—Notwithstanding a slight check to active business on account of local holidays, it is satisfactory to report that Lancashire foundries are specifying still for good quantities of iron, deliveries in the district being estimated by a market authority as heavier in the aggregate than they have been for two or three years. In these circumstances prices continue firm, with Derbyshire No. 3 quoted at 72s., Staffordshire at 73s., and Scottish brands from 91s. to 92s., all per ton delivered Manchester or equal.

THE MIDLANDS.—At the quarterly meeting held at Birmingham last week, transactions in the pig-iron section disclosed little variation in the general position, most of the consumers having covered their requirements by contracts during the last few weeks, while it is reported that good tonnages of iron are going into consumption. Prices are very firmly held, and most of the furnaces are obtaining premiums of up to 2s. 6d. per ton on the minimum zone prices, which rule at 73s. 6d. for Derbyshire No. 3, 74s. 6d. for Staffordshire No. 3, and 70s. for Northants No. 3, including delivery to local stations.

SCOTLAND.—With the works in Glasgow and district closed down for 10 to 14 days, business in pig-iron has shrunk almost to vanishing point. Notwithstanding this interruption of buying, the local furnaces have advanced their basis price for No. 3 foundry by 1s. 6d. per ton, making the quotation 76s. f.o.t. furnaces.

Finished Iron.

Manufacturing firms in the Black Country area report that, apart from the comparatively good demand for Staffordshire marked bars, this market remains dull. It is true that recently conditions have been somewhat better with regard to crown bars, but the position is a long way from being satisfactory. There is much competition for the business maturing from the Midlands, and Lancashire works are taking low prices. Crown iron is quoted at any price from £9 10s. to £10 5s. Marked bars are £12 at works. There is a fair amount of foreign bolt iron coming into the district, solely on account of the price. The Continental product is being sold delivered here at £7 2s. 6d. to £7 5s., while the local works are quoting in the neighbourhood of £9 5s. per ton.

Steel.

Though quiet conditions are reported in some departments most of the British steelworks have a fair amount of work in hand, and are hurrying to complete contracts before the annual holidays begin. The scarcity of new business to take the place of completed contracts, however, is causing some concern. Business is also good in the semi-finished department of the British market, although the situation is not quite so satisfactory as of late, owing to a falling-off in some of the principal consuming branches of the trade. An irregular tone continues to be noticeable in the finished-steel market, and it is in this department that the absence of business is most conspicuous. In the tinplate market makers are generally booked up for two to three months ahead, and are holding firmly to quotations as follow:—Coke tins, 18s. 3d. to 18s. 6d. basis, net cash, f.o.b. Wales.

Scrap.

Markets for scrap metals in most localities are fairly active, the foundries on Tees-side taking average quantities of ordinary heavy cast iron at 66s. per ton, with 68s. 6d. quoted for good machinery quality in handy pieces. In the Midlands, also, the majority of the foundries are busy, and there is a keen demand for cast-iron scrap. Many dealers, however, are of the opinion that prices of this class of material will rise, and are, therefore, only selling small quantities. A price of 70s. to 72s. 6d. is quoted for machinery scrap in cupola sizes, and 60s. per ton for piping and plate scrap. In Scotland the cast-iron scrap market is still flat, with machinery scrap offered at around 70s. for material in pieces not exceeding 1 cwt. Ordinary cast-iron scrap is quoted at 63s. 6d. and light cast-iron scrap at 60s., with firebars at about 57s. 6d. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—The steady decline in warrant copper values of late has, so far, been reflected only to a modified extent, the policy of buyers being apparently to force a reduction in prices by abstention from markets, or by taking supplies only on a hand-to-mouth basis. The results of this movement are now being made apparent, and prices at the moment are showing a marked depression in consequence of the great restraint that has been placed upon the absorbing capacity of the European trade. With regard to the future, consumers are uncertain.

Closing quotations are :—

Cash.—Thursday, £71 13s. 9d. to £71 15s.; Friday, £71 3s. 9d. to £71 6s. 3d.; Monday, £71 2s. 6d. to £71 3s. 9d.; Tuesday, £70 1s. 3d. to £70 2s. 6d.; Wednesday, £70 11s. 3d. to £70 13s. 9d.

Three Months.—Thursday, £72 8s. 9d. to £72 10s.; Friday, £72 1s. 3d. to £72 2s. 6d.; Monday, £71 17s. 6d. to £72; Tuesday, £70 17s. 6d. to £71; Wednesday, £71 7s. 6d. to £71 8s. 9d.

Tin.—An event of outstanding importance in the annals of the world's tin industry and its marketing facilities was inaugurated last week, when Sir Edmund Davis, who presided, disclosed the proposals of the new "Tin Producers' Association, comprising all companies and/or persons engaged in the mining or production of tin ore who shall signify their acceptance of membership," and having for its objects the protection and betterment of the tin-mining industry. It is, of course, impossible to estimate the far-reaching future effects upon markets of the movement above outlined, but it is not anticipated that any immediate disturbance of existing conditions will materialise until later in the autumn on the conclusion of the holiday season.

Official closing prices :—

Cash.—Thursday, £208 2s. 6d. to £208 5s.; Friday, £206 12s. 6d. to £206 15s.; Monday, £210 5s. to £210 10s.; Tuesday, £213 15s. to £214; Wednesday, £214 5s. to £214 10s.

Three Months.—Thursday, £211 to £211 5s.; Friday, £209 17s. 6d. to £210; Monday, £213 12s. 6d. to £213 15s.; Tuesday, £217 7s. 6d to £217 10s.; Wednesday, £217 10s. to £217 12s. 6d.

Spelter.—The demand from consumers is poor, and very little active interest is displayed either in this country or on the Continent. Stocks in London are not excessive, due to the scanty arrivals of metal from Belgium, where supplies have been held up rather than send them to London.

Daily quotations are :—

Ordinary. — Thursday, £25 10s.; Friday, £25 7s. 6d.; Monday, £25 5s.; Tuesday, £25; Wednesday, £25 2s. 6d.

Lead.—The general feeling of disappointment brought about by the fact that the producers found any curtailment of the production unnecessary has been reflected in a certain amount of liquidation during the past week.

Prices have been :—

Soft Foreign Prompt.—Thursday, £22 15s.; Friday, £22 15s.; Monday, £22 16s. 3d.; Tuesday, £22 13s. 9d.; Wednesday, £22 10s.

French Engineers Visit Glasgow.

Members of the French Society of Civil Engineers who have been making a tour of the industrial districts of Britain paid a visit to Glasgow. On July 4 the party visited the works of Messrs. Babcock & Wilcox, Limited, Renfrew, and the shipyard of the Fairfield Shipbuilding & Engineering Company, Govan, in the forenoon. In the afternoon the gentlemen of the party were the guests of the Clyde Navigation Trust at a sail down the river. In the evening the party visited the city chambers, where they were given a civic reception. Baillie Park, Senior Magistrate, who presided in the absence of the Lord Provost, said they always received visitors from France with unmingled feelings of gratification and pleasure, because they never forgot how close had been the friendship between this country and France for many centuries. They were particularly glad to see members of the engineering profession. The West of Scotland had been the nursery for many eminent engineers whose works and labour were known all over the world. M. Cuvelette, vice-president of the Society, responded. The party, after visiting Loch Lomond and Loch Katrine, returned by way of Edinburgh and London to France.

Reports and Dividends.

Gloucester Railway Carriage & Wagon Company, Limited.—Final dividend of 2½ per cent., making 5 per cent., less tax, for the year.

William Asquith (1920), Limited.—Profit, £16,619; reserve for income-tax, £2,150; dividend of 8 per cent. on the preference shares; carried forward, £8,391.

Mint (Birmingham), Limited.—Profit, £1,044; brought in, £3,217; transferred from reserve account, £5,000; preference dividend, £3,840; carried forward, £5,421.

Head, Wrightson & Company, Limited.—Profit, £4,783; brought in, £1,170; transferred from reserve account, £13,000; debenture interest, £6,750; preference dividend, £9,302; carried forward, £1,055.

Midland Railway-Carriage & Wagon Company, Limited.—Loss for year, £3,056; brought in, £26,162; final dividend of 3 per cent. on the preference shares, making 6 per cent.; carried forward, £17,283.

W. & T. Avery, Limited.—Balance of revenue account, including £53,987 brought in, £171,244; final dividend on the ordinary shares of 10 per cent., making 15 per cent.; to reserve, £20,000; carried forward, £54,328.

A MESSAGE from Johannesburg states that the South African Railway Administration has placed an order for 28 railway coaches with the Metropolitan Cammell Carriage Wagon & Finance Company, Limited, of Birmingham. The value of the contract is £78,000.

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FIRE BRICKS,
STONE FLUX,
CASTING CLEANERS,
PIPE NAILS,
SPRIGS,
WIRE BRUSHES,
BELLOWS,
CUPOLAS,
GANISTER,
LOAM AND SAND MILLS,
STUDS,
CHAPLETS,
BRUSHES,
CORE ROPES,
BUCKETS,
SPADES, Etc.

Write for Illustrated Catalogue on Blacking and Foundry Requisites.

What Sirocco Service means to you

Submit your Fan Problems to us.

When you instal a TRADE SIROCCO MARK FAN

It means that you have the knowledge and experience gained from thousands of different Fan applications brought to bear upon your particular problem. We are equally interested in the efficient working of your Fan Installation and our Engineers are always ready to advise you how to obtain the best results.

DAVIDSON & CO. LIMITED.
Sirocco Engineering Works.
BELFAST

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	70	11	3
Three months	71	7	6
Electrolytic	84	0	0
Tough	73	10	0
Best selected	73	10	0
Sheets	110	0	0
India	93	0	0
Wire bars	84	10	0
Do. Aug.	84	10	0
Do. Sept.	84	10	0
Ingot bars	84	10	0
H.C. wire rods	86	15	0
Off. av. cash, June	74	7	9
Do. 3 mths., June	73	19	3⅜
Do., Sttlmnt., June	74	8	0
Do., Electro, June	84	7	0
Do., B.S., June	77	8	1½
Aver. spot price, copper, June	74	7	9
Do. wire bars, June	84	13	9

Solid drawn tubes .. 15½d.
Brazed tubes .. 15½d.
Wire .. 12½d.

BRASS.

Solid drawn tubes .. 13d.
Brazed tubes .. 15d.
Rods, drawn .. 12½d.
Rods, extd. or rlld. .. 8½d.
Sheets to 10 w.g. .. 11½d.
Wire .. 11½d.
Rolled metal .. 10½d.
Yellow metal rods .. 8½d.
Do. 4 × 4 Squares .. 9d.
Do. 4 × 3 Sheets .. 9½d.

TIN.

	£	s.	d.
Standard cash	214	5	0
Three months	217	10	0
English	215	0	0
Bars	216	0	0
Straits	217	5	0
Australian	209	0	0
Eastern	219	15	0
Banca	Nominal		
Off. av. cash, June	200	5	9¾
Do., 3 mths., June	203	9	6
Do., Sttlmt., June	200	5	4½
Aver. spot, June	200	5	9¾

SPELTER.

	£	s.	d.
Ordinary	25	2	6
Remelted	23	0	0
Hard	21	0	0
Electro 99.9	27	5	0
English	25	7	6
India	22	0	0
Zinc dust (Nom.)	34	10	0
Zinc ashes	8	15	0
Off. aver., June	26	2	0
Aver., spot, June	26	4	3¾

LEAD.

	£	s.	d.
Soft foreign ppt.	22	10	0
English	24	0	0
Off. average, June	23	12	11½
Average spot, June	23	13	10½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	34	10	0
Do. V.M. ex-whf.	32	12	6
Rods	40	0	0
Boiler plates	30	10	0
Battery plates	31	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	50	5	0
Chinese	32	5	0
Crude	Nominal		

QUICKSILVER.

Quicksilver .. 22 0 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	7	15	0
45/50%	12	0	0
75%	19	10	0

Ferro-vanadium—
35/50% .. 12/10½ lb. Va.
Ferro-molybdenum—
70/75% c. free .. 4/- lb. Mo.
Ferro-titanium—
23/25% carbonless .. 11d. lb.
Ferro-phosphorus, 20/25% .. £16 0 0
Ferro-tungsten—
80/85%, c. fr. .. 2/9 lb.
Tungsten metal powder—
98/99% .. 3/- lb.
Ferro-chrome—
2/4% car. .. £32 10 0
4/6% car. .. £23 15 0
6/8% car. .. £23 0 0
8/10% car. .. £22 15 0
Ferro-chrome—
Max. 2% car. .. £33 15 0
Max. 1% car. .. £37 12 6
Max. 0·70% car. .. £41 10 0
70% carbonless .. 1/2 lb.
Nickel—99% cubes, or pellets £175 0 0
Ferro-cobalt .. 9/4 lb.
Aluminium 98/99% .. £95 0 0
Metallic chromium—
96/98% .. 2/6 lb.
Ferro-manganese (net)—
76/80% loose .. £13 15 0
76/80% packed .. £14 15 0
76/80%, export .. £14 10 0
Metallic manganese—
94/96%, carbonless .. 1/6 lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten £0 2 0
Finshed bars, 18% tungsten £0 2 9
Per lb. net, d/d buyers' works.
Extras—
Rounds and squares, 3 in. and over .. 4d. lb.
Rounds and squares, under ½ in. to ¼ in. .. 3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in. .. 1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ¼ in. .. 3d. lb.
Do., under ¼ in. × ¼ in. .. 1/- lb.
Bevels of approved sizes and sections .. 6d. lb.
Bars cut to length, 10% extra

SCRAP.

South Wales—	£	s.	d.		£	s.	d.
Heavy steel	3	17	0	to	3	18	0
Bundled steel and shrngs.	3	13	6	to	3	16	0
Mixed iron and steel	3	10	0	to	3	11	0
Heavy cast iron					3	2	6
Good machinery for foundries	3	5	0	to	3	7	6
Cleveland—							
Heavy steel					3	5	0
Steel turnings					2	17	6
Cast iron borings					2	17	6
Heavy forge					3	17	6
W.I. piling scrap					3	12	6
Cast-iron scrap	3	6	0	to	3	8	6
Lancashire—							
Cast-iron scrap	3	0	0	to	3	10	0
Hvy. wrought					3	12	6
Steel turnings					2	17	6
Scotland—							
Heavy steel					3	15	6
Cast-iron borings					2	14	6
Wrought-iron piling					3	13	0
Heavy machinery					3	10	0

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	62	0	0
Brass	41	0	0
Lead (less usual draft)	20	0	0
Tea lead	16	10	0
Zinc	17	0	0
New aluminium cuttings	68	0	0
Braziery copper	54	0	0
Gunmetal	54	0	0
Hollow pewter	150	0	0
Shaped black pewter	106	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—
Foundry No. 1 .. 75/-
Foundry No. 3 .. 72/6
Foundry No. 4 .. 71/6
Forge No. 4 .. 71/-
Hematite No. 1 .. 75/6
Hematite M/Nos. .. 75/-

N.W. Coast—
Hem. M/Nos. d/d Glas. .. 86/-
„ d/d Birm. .. 92/-

Midlands—
Staffs. common* .. —
„ No. 4 forge* .. 70/6
„ No. 3 fdry* .. 74/6
Shrops. basic .. —
„ Cold blast, ord. .. —
„ „ roll iron .. —
Northants forge* .. 66/-
„ fdry. No. 3* .. 70/-
Derbyshire forge* .. 69/6
„ fdry. No. 3* .. 73/6
„ basic* .. —
* d/d Black Country dist.

Scotland—
Foundry No. 1 .. 78/6
„ No. 3 .. 76/-
Hem. M/Nos. .. 80/-

Sheffield (d/d district)—
Derby forge .. 64/6
„ fdry. No. 3 .. 68/6
Lincs. forge .. —
„ fdry. No. 3 .. 72/6
E.C. hematite .. 86/-
W.C. hematite .. 87/-

Lincs. (at furnaces)—
Forge No. 4 .. —
Foundry No. 3 .. —
Basic .. —

Lancashire (d/d eq. Man.)—
Derby forge .. —
„ fdry. No. 3 .. 72/-
Northants foundry No. 3 .. —
Dalzell, No 3 (special) 102/6 to 105/-
Summerlee, No. 3 .. 92/-
Glengarnock, No. 3 .. —
Gartsherrie, No. 3 .. 92/-
Monkland, No. 3 .. 92/-
Shotts, No. 3 .. 92/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.) nom.					10	15	0
Nut and bolt iron					9	5	0
Hoops	11	0	0	to	11	10	0
Marked bars (Staffs.) f.o.t.					12	0	0
Gas strip	11	0	0	to	11	10	0
Bolts and nuts, ¾ in. × 4 in.					15	5	0
Steel—							
Ship plates	8	12	6	to	8	17	6
Boiler plts.					10	10	0
Chequer plts.					10	12	6
Angles					8	2	6
Tees					9	2	6
Joists					8	2	6
Rounds and squares, 3 in. to 5½ in.					9	2	6
Rounds under 3 in. to ¾ in. (Untested)					8	0	0
					and upwards		
Flats, over 5 in. wide and up					8	7	6
Flats, 5 in. to 1½ in.					7	17	6
Rails, heavy					8	10	0
Fishplates					12	10	0
Hoops (Staffs.)	10	0	0	to	10	10	0
Black sheets, 24g.	10	5	0	to	10	10	0
Galv.cor.shts., 24g.	13	2	6	to	13	10	0
Galv. fencing wire 8g. plain	12	0	0				
Billets, soft	6	7	6	to	6	17	6
Billets, hard	7	10	0	to	8	2	6
Sheet bars	6	5	0	to	6	10	0
Tin bars	6	5	0	to	6	10	0

PHOSPHOR BRONZE.

Per lb. basis.

Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6½
Rods	1/5
Tubes	1/9½
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	15.00
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.95
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.30
Tinplates, 100 lb. box	$5.35

COKE (at ovens).

Welsh foundry	25/- to 27/6
„ furnace	21/- to 25/-
Durham and North.	
„ foundry	18/6 to 20/6
„ furnace	19/-
Midlands, foundry	—
„ furnace	19/- and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/3
„	28×20 „	36/6
„	20×10 „	26/3
„	18½×14 „	18/9
C.W.	20×14 „	15/3
„	28×20 „	33/6
„	20×10 „	21/3
„	18½×14 „	16/-
Terneplates	28×20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0	to	£7	10	0
Bars, hammered, basis	£17	10	0	to	£18	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	15	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£32	0	0	to	£33	0	0
Faggot steel	£20	0	0	to	£24	0	0
Bars and rods, dead soft, steel	£10	0	0	to	£14	0	0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.
Up to and incl. 6 in.

	Tubes.	*Fittings:*
Gas	67½%	50%
Water	63½%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£ s. d.		
July	11 ..	71 13 9	No	change
„	12 ..	71 3 9	dec.	10/-
„	15 ..	71 2 6	„	1/3
„	16 ..	70 1 3	„	21/3
„	17 ..	70 11 3	inc.	10/-

Electrolytic Copper.

		£ s. d.		
July	11 ..	84 0 0	No	change
„	12 ..	84 0 0	„	„
„	15 ..	84 0 0	„	„
„	16 ..	84 0 0	„	„
„	17 ..	84 0 0	„	„

Standard Tin (cash).

		£ s. d.		
July	11 ..	208 2 6	inc.	52/6
„	12 ..	206 12 6	dec.	30/-
„	15 ..	210 5 0	inc.	72/6
„	16 ..	213 15 0	„	70/-
„	17 ..	214 5 0	„	10/-

Tin (English ingots).

		£ s. d.		
July	11 ..	208 10 0	inc.	50/-
„	12 ..	207 0 0	dec.	30/-
„	15 ..	210 10 0	inc.	70/-
„	16 ..	214 0 0	„	70/-
„	17 ..	215 0 0	„	20/-

Zinc Sheets (English).

		£ s. d.		
July	11 ..	34 10 0	No	change
„	12 ..	34 10 0	„	„
„	15 ..	34 10 0	„	„
„	16 ..	34 10 0	„	„
„	17 ..	34 10 0	„	„

Spelter (ordinary).

		£ s. d.		
July	11 ..	25 10 0	dec.	5/-
„	12 ..	25 7 6	„	2/6
„	15 ..	25 5 0	„	2/6
„	16 ..	25 0 0	„	5/-
„	17 ..	25 2 6	inc.	2/6

Lead (English).

		£ s. d.		
July	11 ..	24 5 0	dec.	5/-
„	12 ..	24 5 0	No	change
„	15 ..	24 5 0	„	„
„	16 ..	24 0 0	dec.	5/-
„	17 ..	24 0 0	No	change

AVERAGE MONTHLY PRICES OF IRON HOOPS.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 5 0	6 10 0	6 3 0
1897	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 8
1898	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	7 0 0	6 11 6	6 11 6
1899	7 0 0	7 0 0	7 0 0	7 0 0	7 12 6	10 12 6	8 12 6	8 12 6	8 12 6	9 2 6	9 7 6	9 17 6	8 2 9
1900	9 17 6	10 7 6	10 7 6	10 7 0	10 12 6	7 12 6	10 12 6	10 12 6	10 12 6	9 17 6	9 2 6	9 2 6	10 3 8
1901	9 2 6	8 2 6	8 2 6	7 12 6	7 12 6	7 12 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 11 2
1902	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6
1903	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 0
1904	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6
1905	6 17 6	7 0 0	7 0 0	7 0 6	7 0 0	7 0 0	7 2 6	7 2 6	7 2 6	7 7 6	7 0 0	7 7 6	7 2 0½
1906	7 10 0	7 17 6	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 7 6	7 15 1½
1907	8 7 6	8 7 6	8 7 6	8 7 0	8 7 6	8 7 6	8 10 0	8 10 0	8 10 0	8 5 0	8 5 0	8 0 0	8 7 1
1908	8 0 0	7 10 0	7 10 0	7 10 6	7 10 0	7 10 0	7 10 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 6 8
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0
1910	7 1 10½	7 6 3	7 7 6	7 7 0	7 7 6	7 7 6	7 7 6	7 7 6	7 7 6	7 6 3	7 5 0	7 5 0	7 6 5
1911	7 5 0	7 5 0	7 5 0	7 5 6	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 8 9	7 10 0	7 10 0	7 6 2½
1912	7 12 6	7 12 6	7 12 6	7 15 0	7 15 0	8 2 6	8 2 6	8 2 6	8 12 6	8 12 6	8 12 6	8 15 0	8 2 3½
1913	8 17 6	8 17 6	8 17 6	8 17 0	8 17 6	8 17 6	8 17 6	8 7 6	8 7 6	8 7 6	8 7 6	7 17 6	8 12 6
1914	7 17 6	7 17 6	7 17 6	7 13 9	7 12 6	7 12 6	7 12 6	9 2 6	9 2 6	9 2 6	9 2 6	9 2 6	8 6 4½
1915	9 3 6	9 18 1	10 7 6	10 16 6	10 17 6	13 2 6	13 2 6	13 2 6	13 7 6	14 2 6	15 2 6	15 18 6	12 10 1
1916	17 2 6	17 2 6	17 2 6	17 6 3	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 6 1
1917	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6
1918	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6
1919	17 2 6	17 2 6	17 2 6	17 2 6	24 6 3	24 6 3	24 6 3	25 9 0	26 7 6	26 7 6	26 7 6	26 17 4	22 14 9
1920	28 0 0	28 12 6	33 15 0	35 5 0	35 15 10	38 17 6	38 17 6	38 17 6	38 17 6	38 17 6	36 17 6	36 17 6	35 14 9
1921	29 1 3	23 5 0	21 12 6	20 0 0	20 0 0	20 0 0	17 5 0	15 0 0	14 4 0	13 15 0	13 10 0	12 18 0	17 5 10
1922	16 5 0	15 13 9	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	13 4 6½
1923	14 0 0	15 0 0	15 0 0	15 0 0	15 6 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	14 16 0	14 15 0	14 18 3½
1924	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 13 9	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 12 4½
1925	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0
1926	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0
1927	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	12 10 0	12 10 0	14 3 4
1928	12 10 0	12 7 6	12 0 0	11 13 6	11 15 0	11 12 6	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 14 10½
1929	11 10 0	11 10 0	11 10 0	11 10 0	11 9 0	11 5 0	—	—	—	—	—	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

PIG IRON

REGISTERED TRADE MARK

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-.

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED.

FOUNDRY FOREMAN, with thorough practical and technical training, desires position where experience and ability is required; up to date on all classes of iron and non-ferrous work, mix all metals by analysis; McLain and I.C.S. graduate; take entire charge of foundry and pattern shop.—Box 268, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EX-PUBLIC SCHOOL MAN (24), now journeyman moulder, requires position as Foundry Manager's Assistant, or similar post, where practical and technical knowledge would be of use; would serve for short time without remuneration if prospects good.—Box 266, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PIG-IRON.—Engineer with intensive Foundry and Sales experience, etc., is open to travel Midland Counties for important blast-furnace company.—Address, Box 272, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

AGENCY.

WANTED, First-class District Agents to sell all classes of Foundry Plant and Equipment in the following areas:—

Manchester, Sheffield,
Leeds, Newcastle-on-Tyne,
Middlesbrough, Birmingham,
Leicester.

Generous commission paid.

Apply, Box 274, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

AUCTION.

Re R. C. WHIPP & COMPANY, LIMITED, BEEHIVE FOUNDRY, TIVIDALE, STAFFS.

By Order of the Receiver and Manager for the Debenture Holders.

Important Sale by Public Auction in One Lot as a Going Concern of the above

IMPORTANT FOUNDRY BUSINESS,

Makers of

SOFT GREY IRON CASTINGS AND SOLID SPINDLE PARALLEL VICES.

MR. DUNCAN J. SHEDDEN, F.A.I., is instructed by the Receiver and Manager for the Debenture Holders to offer for Sale by Public Auction in One Lot, subject to Conditions of Sale to be read at the time, on

WEDNESDAY, JULY 31, 1929, at the VICTORIA HOTEL, WOLVERHAMPTON,

At 4 p.m. punctually,

Comprising

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